WATER OPERATION AND MAINTENANCE

BULLETIN NO. 116

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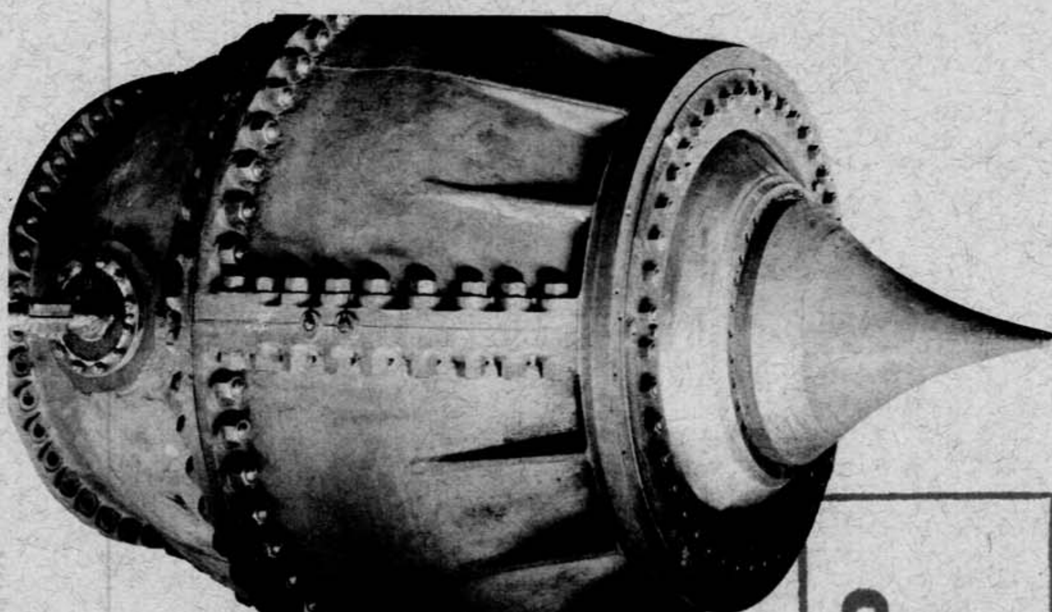

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NEEDLE VALVES

UNITED STATES DEPARTMENT OF THE INTERIOR
Bureau of Reclamation

WATER OPERATION AND MAINTENANCE
BULLETIN NO.116

June 1981

PREFACE

Water Operation and Maintenance Bulletin No. 116 is devoted exclusively to a presentation of needle valves–the various types, problems, operating practices, and repair procedures.

Material for the article on needle valves was provided by E. O. Green, Mechanical Engineer (retired), E&R Center; and Harvey J. Olberding, Foreman II, Maintenance, Black Canyon Field Branch, Central Snake Projects Office. Special recognition is due to these dedicated Bureau of Reclamation employees who blended the talents of design and construction with operation and maintenance experience in developing the needle valve material for this special Water O&M Bulletin. Mr. Lee Gerbig, Mechanical Engineer, E&R Center, assembled and edited the drawings and figures used in the article.

The Water O&M Bulletin is published quarterly for the benefit of those operating water-supply systems. Its principal purpose is to serve as a medium of exchanging operation and maintenance information. It is hoped that the laborsaving devices and less costly equipment developed by the resourceful water users will be a step toward commercial development of equipment for use on irrigation projects in continued effort to reduce costs and increase operating efficiency.

Division of Operation and
Maintenance Technical Services
Engineering and Research Center
Denver, Colorado 80225

In May of 1981, the Secretary of the Interior approved changing the Water and Power Resources Service back to its former name, the Bureau of Reclamation.

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INTRODUCTION

Scope

Needle valves of various types have been installed on USBR (Bureau of Reclamation) projects since the early days of the Bureau until the 1940's. All of these valves were designed by the Bureau and are used as control valves to regulate flow from the reservoir through the dam outlets.

The early type valve used until about 1920 was the "balanced valve" or more commonly referred to as the "ensign valve." The ensign valves were designed to be installed on the upstream face of the dam at the entrance to the outlet conduits and were water hydraulically operated.

The first of the line of valves referred to herein as needle valves was designed about 1920 and named "balanced needle valve." Later designs are called "internal differential needle valve" and "interior differential needle valve."

The above three types of needle valves are water hydraulically operated. A few smaller sized needle valves are mechanically screw operated. The needle valves are designed to be installed on the downstream end of the outlet pipe and to discharge freely into a stilling basin or directly into the river.

The tube valve developed about 1940 is an outgrowth of the needle valve. It is essentially a needle valve without the internal water chambers and with the needle shortened until it is an open ended tube. The tube valves are mechanically screw or oil hydraulic operated.

The operating history of needle valves at various projects has been rated through a range from good down to unreliable. In general, the higher the rating, the better the valve has been maintained. But this is not always true as the water quality and other local conditions can significantly influence the amount of maintenance required on water-operated valves. Needle valves do require more maintenance than other types of regulating gates and valves. If needle valves are not well maintained, they will become unreliable.

Many years of operating and maintenance experience have been gained on needle valves. It is important that the knowledge accumulated through the years be recorded for the benefit of all present and future operating and maintenance personnel.

General Description of Needle Valves

Needle valves are constructed with their axis in line with the axis of the outlet pipes. The working parts are in the center of the valve located along the axis and are attached to the outer body by ribs. The body must be enlarged to form a water passage between the internal parts and the body and then gradually reduced to the seat on the downstream end. The movable control element is called a needle as the downstream end is tapered to a point. The needle is held against the body seat to close off flow and is moved upstream to allow flow. Water contained in chambers inside the valve and acting on plungers or pistons controls the movement of the needle. Valving is provided to control the flow of water into and out of the chambers. The valving is actuated by a control handwheel and by the movement of the needle. When the handwheel is turned, the valving is actuated to produce needle movement in the desired direction. The needle movement returns the valving to a neutral position. In the neutral position, all forces in the valve chambers are balanced holding the needle in this set position. If the needle drifts from the set position, the valving is actuated to return the needle to position. The arrangement of the chambers is different in each type of valve and there are even more variations of control valving but this general principal of operation applies to all. Normally, reservoir water at existing reservoir head is used to operate the needle valves.

The principals of operation and control are much the same for the ensign valve as for the needle valves. The construction of the ensign valve is somewhat different as the body does not contain a water passage as such. The main part of the valve is attached by ribbing to a large downstream ring which is bolted to the upstream face of the dam. Water from the reservoir flows through this ribbed area into the outlet conduit controlled by a movable needle.

Materials used in the construction of the needle valves vary, but the following general statements can be made: the bodies and the large structural parts were normally made of cast iron, semisteel, or cast steel; bronze was also used for some of the large castings; and bronze was normally used for seats, liners, bull rings, bushings, and other parts in sliding contact.

Types of Needle Valves

Ensign (Balanced) Valve

Figure 1 is a diagram of the ensign valve showing the arrangement of the principal parts and operating chambers. Figure 2 (drawing 4-E-36) shows the general assembly of a 58-inch ensign valve. The needle on this type valve was made as an integral part of a cylindrical piston with a bull ring of larger diameter on the upstream end. The bull ring fits into a stationary cylinder in which it moves laterally. Reservoir water acting directly on the downstream face of the bull ring provides the opening force for the needle assembly. Clearance was provided between the bull ring and the cylinder liner to allow a limited flow of water past the bull ring into the upstream (closing) chamber. A movable control tube in conjunction with a poppet mounted on the needle provides control of water flowing out of this chamber. As the tube is extended restricting flow, the needle is forced downstream. As the tube is retracted, water flows out of the chambers faster than it comes in and the needle moves upstream. With the tube held stationary, the needle remains in position allowing water to flow out of the chamber at the same rate it comes in. Movement

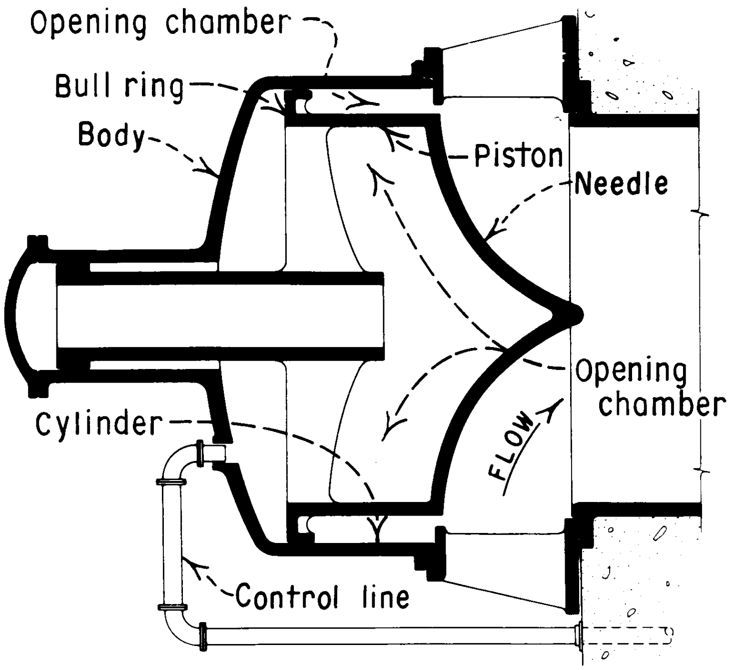


Figure 1.–Ensign (balanced) valve.

of the control tube is provided by a handwheel through shafting, a gear set, and screw drive. Some ensign valves were made without the control tube and can be used only in the fully open or fully closed positions.

Balanced Needle Valve

Figure 3 is a diagram of the balanced needle valve showing the arrangement of the principal parts and operating chambers. Figure 4 (drawing 100-E-105) shows the general assembly of a 60-inch balanced needle valve. The needle on this type valve is attached to a cylindrical piston with a bull ring of larger diameter on the upstream end. The valve body is made large enough to receive this bull ring and is fitted on the inside surface with a bronze liner. The bull ring fits closely in the cylindrical liner and moves laterally to impact closing and opening travel to the needle. The downstream side of the bull ring is open to the valve waterway and subject to reservoir water pressure as long as the valve is watered-up. (This arrangement is very similar to the ensign valve.) The interior of the valve body and the interior of the needle-piston assembly form one large water chamber (closing chamber). Water enters the closing chamber, both by leakage around the bull ring and through a pitot valve located in the top splitter of the valve body. The pitot valve is adjustable, but once adjusted is normally left in that position. Drainage from the closing chambers passes through a control unit mounted on top of the needle valve. This unit is fitted with two concentric sleeves. One sleeve is rotated by movement of the control handwheel and the other by movement of the needle. Overlapping ports in these sleeves control the flow of drainage water. When the handwheel sleeve is moved to increase

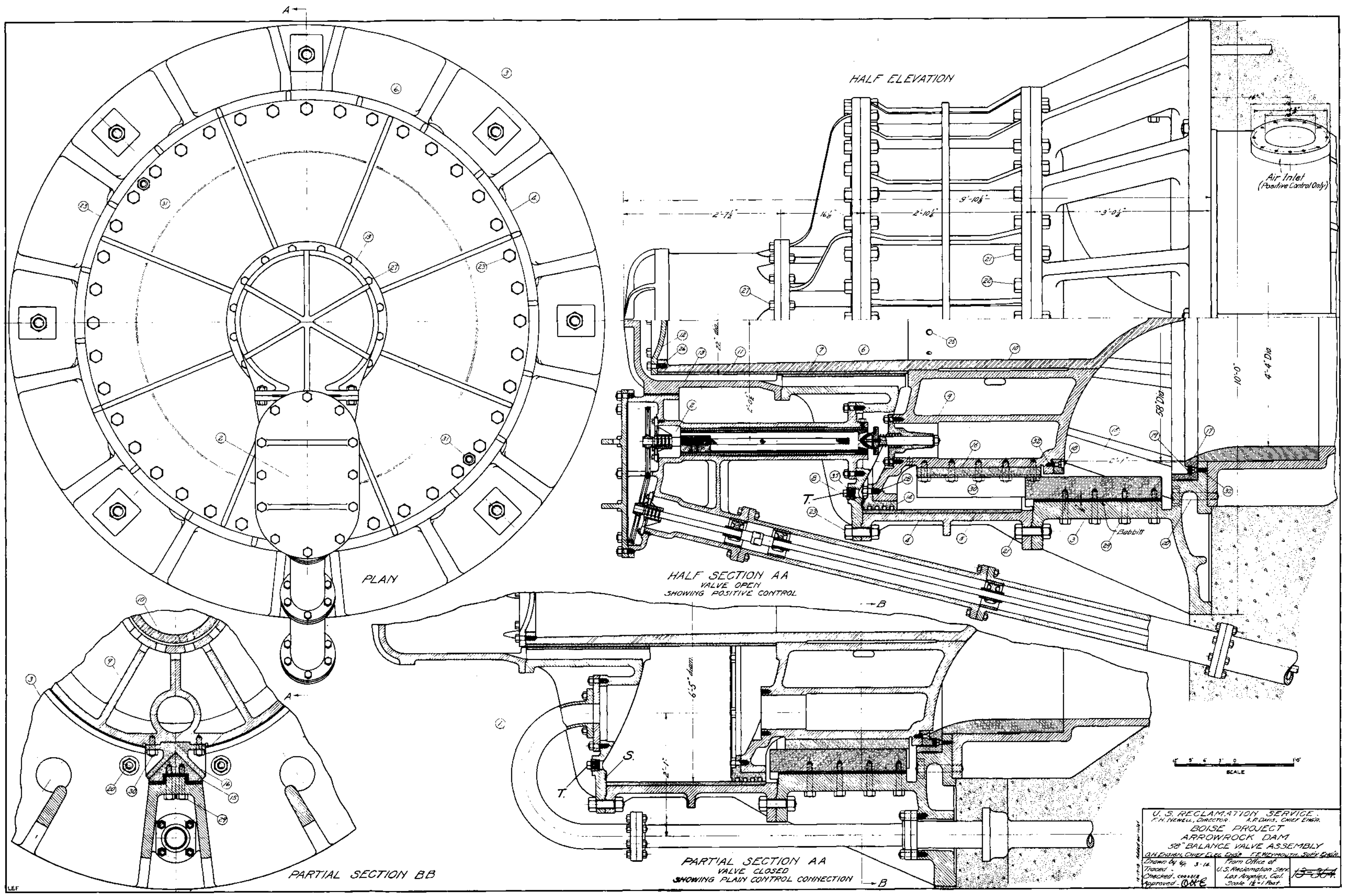


Figure 2.–Drawing 4-E-36, general assembly of 58-inch ensign valve.

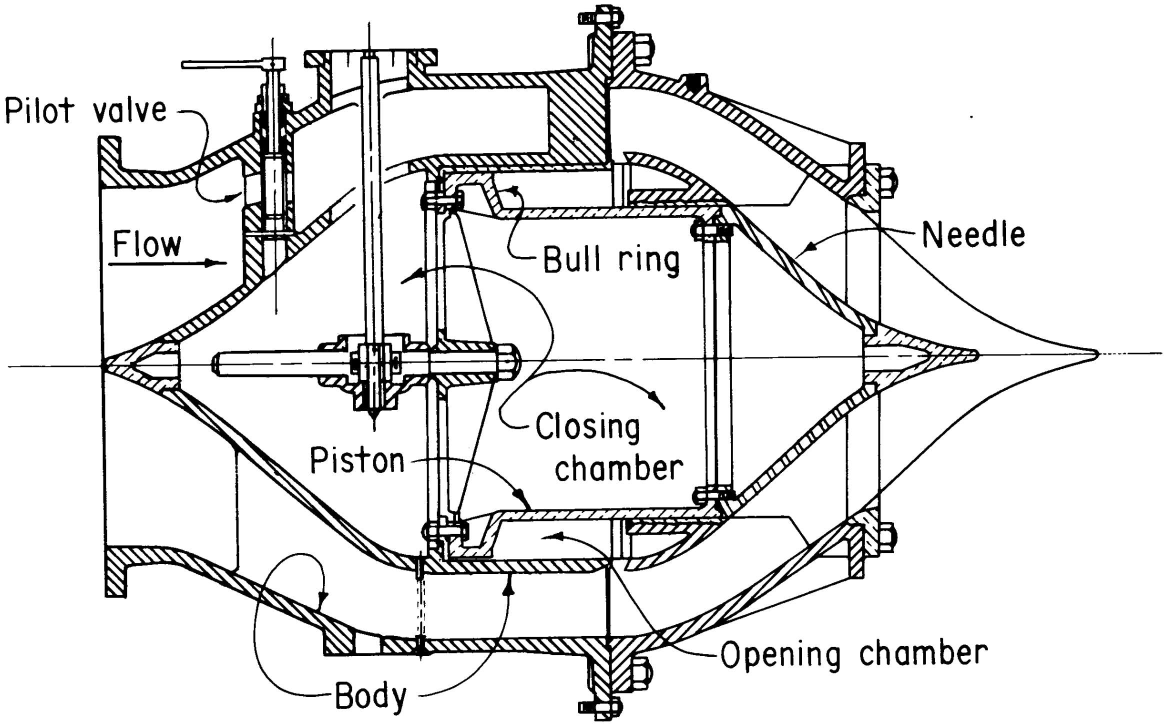


Figure 3.–Balanced needle valve.

flow, the needle moves in the opening direction until movement of the needle-driven sleeve causes flow in and out of the chamber to balance. In a like manner, opposite motion of the handwheel controls the closing movement of the needle.

Some balanced needle valves are equipped with other types of control units. Two other types will be mentioned here. In both of these, water is supplied to the interior chamber only by designed-in leakage around the bull ring. On the valve at Pathfinder Dam, the drainage water and the movement of the needle are controlled by a movable tube and poppet arrangement mounted in the valve chamber. This control tube functions in like manner to the one for the ensign valve described above. On the valve at Buffalo Bill Dam, the flow of drainage water is controlled by an exterior poppet valve. The position of this poppet is controlled by both a handwheel and movement of the needle through a shaft and rack-and-pinon arrangement. In like manner to the sleeved control unit described above, the poppet valve, by controlling the flow of drainage water, controls the opening and closing movements of the needle.

Internal Differential Needle Valve

Figure 5 is a diagram of the internal differential needle valve showing the arrangement of the principal parts and operating chambers.

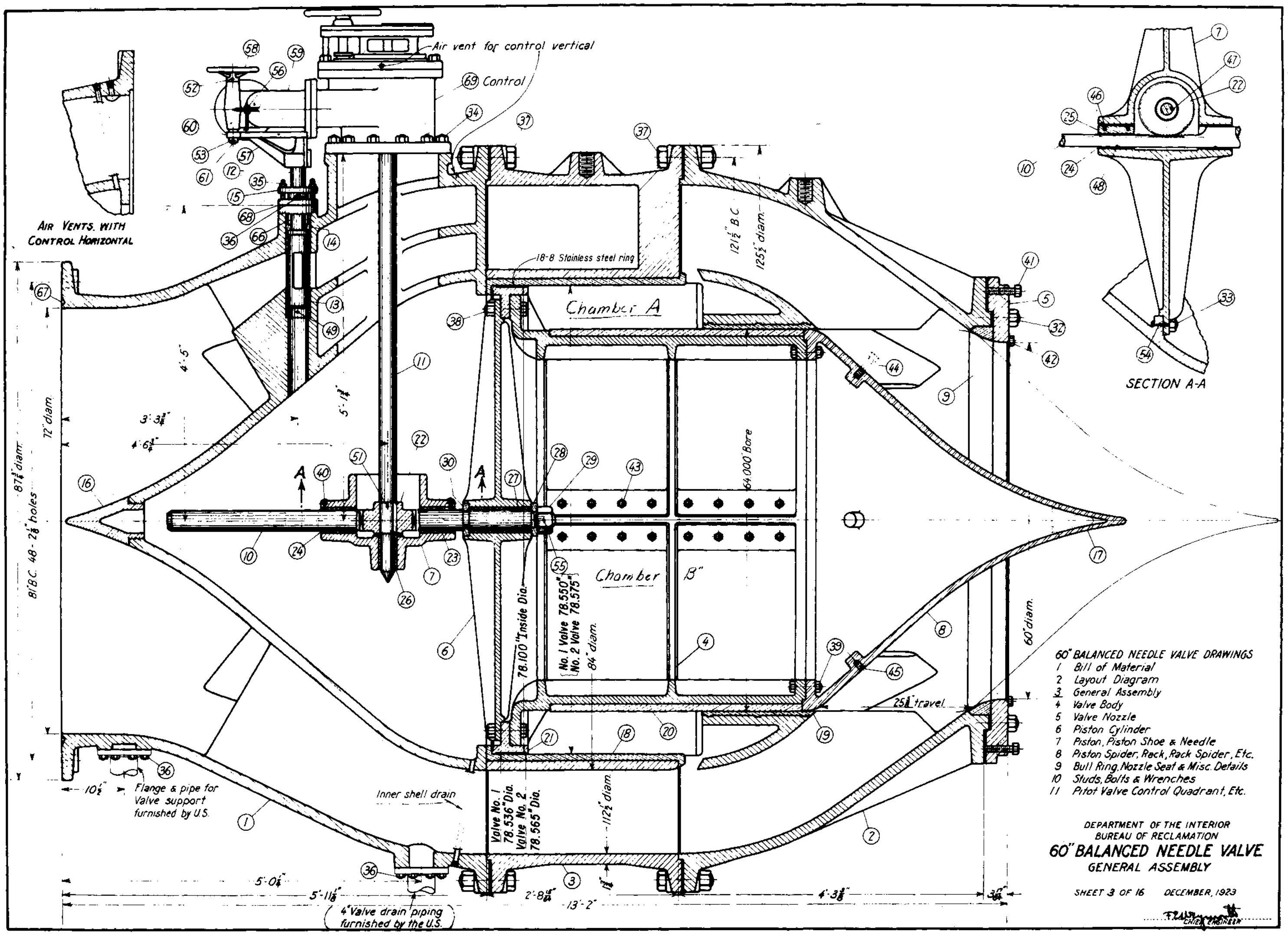


Figure 4.–Drawing 100-E-105, general assembly of 60-inch balanced needle valve.

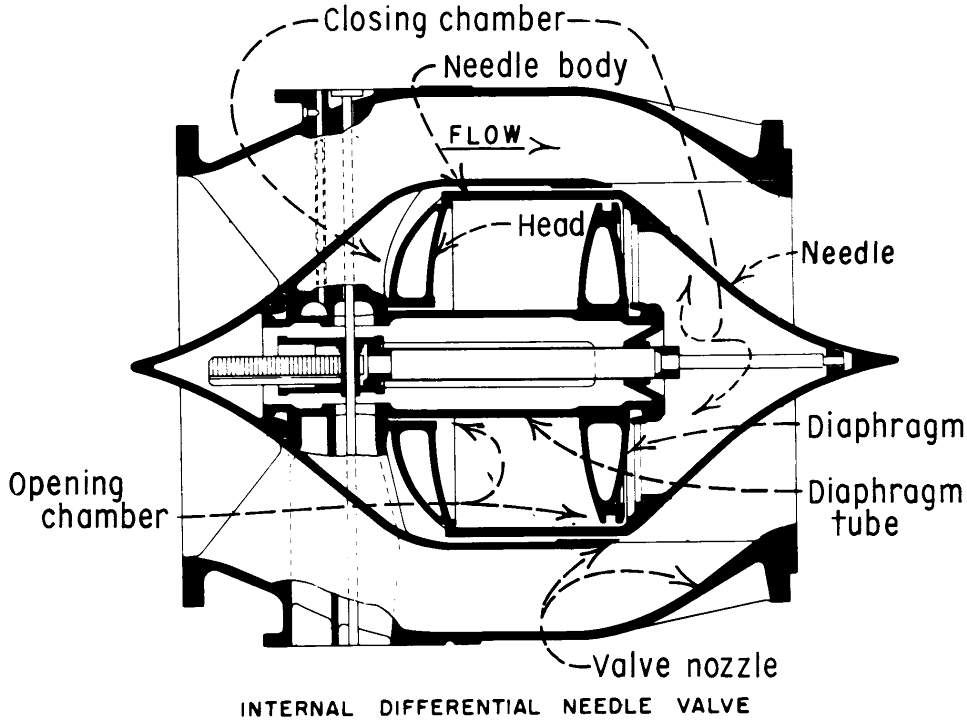
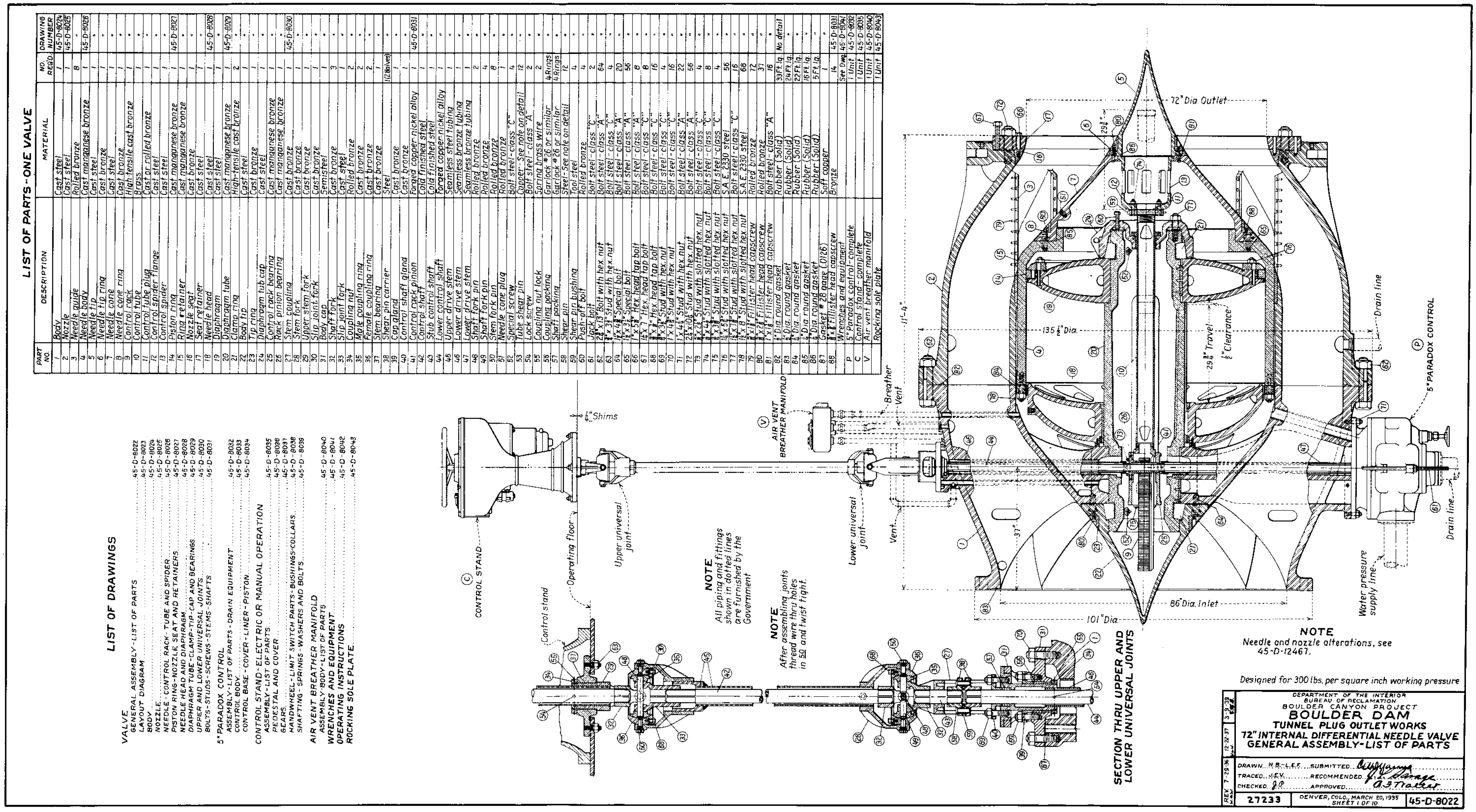


Figure 5.–Internal differential needle valve.

Figure 6 (drawing 45-D-8022) shows the general assembly of a 72-inch internal differential needle valve, and figure 7 (drawing 40-D-600) shows the operating instructions for this type valve. The needle assembly on this type valve is provided with a long cylindrical body which slides on a bronze liner and bronze guides in the valve nozzle. A head is attached to the upstream end of the needle body. A diaphragm tube is attached to the valve body and extends through a closely fitted opening in the needle head. A diaphragm is mounted on the downstream end of the diaphragm tube and seals against the interior surface of the needle body with a large piston ring. This arrangement creates three chambers in the valve. The upstream and downstream chambers are interconnected and water pressure in these chambers produces a closing force on the needle. Water pressure in the middle chamber produces an opening force on the needle.

A paradox control, figure 8 (drawing 40-D-1090), is normally provided on these valves to direct water flow to and from the internal chambers. The paradox control is connected to a water-supply line, to a drain line, and to the opening and closing chambers of the valve. In today's parlance, it would be called servovalve. It is fitted with a removable control piston (spool). Endwise movement of the piston is controlled by both the handwheel on the control stand and through a rack-and-pinion arrangement on the needle. With the piston at midpoint of travel, the water supply to the paradox control, the drain line, and the waterlines to the needle valve chambers are all blocked creating a no-flow condition and the needle is held in the set position. When the handwheel is turned, it moves the



LIST OF PARTS-ONE VALVE

PART NO.	DESCRIPTION	MATERIAL	NO. REQ'D.	DRAWING NUMBER
1	Body	Cast steel	1	45-D-8024
2	Nozzle	Cast steel	1	45-D-8025
3	Needle guide	Rolled bronze	8	"
4	Needle body	Cast manganese bronze	1	45-D-8026
5	Needle tip	Cast steel	1	"
6	Needle tip ring	Cast bronze	1	"
7	Needle cone	Cast steel	1	"
8	Needle cone ring	Cast bronze	1	"
9	Control rack	High-tensile cast bronze	1	"
10	Control tube	Brass	1	"
11	Control tube plug	Cast or rolled bronze	1	"
12	Control spider flange	Cast steel	1	"
13	Control spider	Cast steel	1	"
14	Piston ring	Cast manganese bronze	1	45-D-8027
15	Ring retainer	Cast manganese bronze	1	"
16	Nozzle seat	Cast bronze	1	"
17	Seat retainer	Cast steel	1	"
18	Needle head	Cast steel	1	45-D-8028
19	Diaphragm	Cast steel	1	"
20	Diaphragm tube	Cast manganese bronze	1	45-D-8029
21	Clamp ring	High-tensile cast bronze	2	"
22	Body tip	Cast steel	1	"
23	Tip ring	Cast bronze	1	"
24	Diaphragm tub cap	Cast steel	1	"
25	Control rack bearing	Cast manganese bronze	1	"
26	Rack pinion bearing	Cast manganese bronze	1	"
27	Stem coupling	Cast bronze	1	45-D-8030
28	Stem fork	Cast bronze	1	"
29	Upper stem fork	Cast bronze	1	"
30	Slip joint fork	Cast bronze	1	"
31	Body cap	Semisteel	1	"
32	Shaft fork	Cast bronze	3	"
33	Slip joint fork	Cast steel	1	"
34	Coupling nut	Rolled bronze	2	"
35	Male coupling ring	Cast bronze	2	"
36	Female coupling ring	Cast bronze	2	"
37	Stem bearing	Cast bronze	1	"
38	Shear pin carrier	Steel	1(2 Halves)	"
39	Cap gland	Cast bronze	1	"
40	Control shaft gland	Cast bronze	1	"
41	Control rack pinion	Forged copper-nickel alloy	1	45-D-8031
42	Control shaft	Cold finished steel	1	"
43	Stub control shaft	Cold finished steel	1	"
44	Lower control shaft	Forged copper-nickel alloy	1	"
45	Upper drive stem	Seamless steel tubing	1	"
46	Lower drive stem	Seamless bronze tubing	1	"
47	Lower drive stem	Seamless bronze tubing	1	"
48	Shaft fork pin	Rolled bronze	2	"
49	Shaft fork pin	Rolled bronze	4	"
50	Stem fork pin	Rolled bronze	8	"
51	Needle cone plug	Rolled bronze	1	"
52	Special screw	Bolt steel-class "C"	4	"
53	Tube shear pin	Copper-See note on detail	12	"
54	Lock screw	Bolt steel-class "A"	2	"
55	Coupling nut lock	Spring brass wire	2	"
56	Coupling packing	Garlock #26 or similar	4 Rings	"
57	Shaft packing	Garlock #26 or similar	4 Rings	"
58	Shear pin	Steel-See note on detail	12	"
59	Shear pin bushing	Tool steel	4	"
60	Push-off bolt	Rolled bronze	4	"
61	Jack bolt	Bolt steel-class "C"	2	"
62	2 1/4"x13" Bolt with hex. nut	Bolt steel-class "A"	64	"
63	3/4"x3 1/2" Stud with hex. nut	Bolt steel-class "C"	4	"
64	1 1/2"x4 3/8" Special bolt	Bolt steel-class "A"	20	"
65	1 1/2"x3 1/2" Special bolt	Bolt steel-class "A"	56	"
66	1"x5 7/8" Hex. head tap bolt	Bolt steel-class "A"	8	"
67	1 1/4"x7" Hex. head tap bolt	Bolt steel-class "C"	8	"
68	5/8"x7/8" Hex. head tap bolt	Bolt steel-class "C"	16	"
69	5/8"x3 3/8" Stud with hex. nut	Bolt steel-class "C"	4	"
70	1"x4 3/4" Stud with hex. nut	Bolt steel-class "C"	16	"
71	1"x4 1/4" Stud with hex. nut	Bolt steel-class "A"	22	"
72	2 1/4"x10 1/4" Stud with hex. nut	Bolt steel-class "A"	56	"
73	5/8"x2 1/2" Stud with slotted hex. nut	Bolt steel-class "C"	4	"
74	7/8"x4 1/4" Stud with slotted hex. nut	Bolt steel-class "C"	8	"
75	3/4"x3 3/8" Stud with slotted hex. nut	Bolt steel-class "C"	4	"
76	1 1/4"x5 3/4" Stud with slotted hex. nut	S.A.E. 2330 steel	56	"
77	1 1/2"x7 3/4" Stud with slotted hex. nut	Bolt steel-class "C"	16	"
78	1 1/2"x8" Stud with slotted hex. nut	S.A.E. 2330 steel	68	"
79	3/8"x1 3/8" Fillister head capscrew	Rolled bronze	72	"
80	5/8"x2 3/8" Fillister head capscrew	Rolled bronze	37	"
81	1"x1 3/8" Fillister head capscrew	Bolt steel-class "A"	16	"
82	1/2" Dia. round gasket	Rubber (Solid)	33 Ft. lg.	No detail
83	1/2" Dia. round gasket	Rubber (Solid)	24 Ft. lg.	"
84	1/4" Dia. round gasket	Rubber (Solid)	22 Ft. lg.	"
85	1/4" Dia. round gasket	Rubber (Solid)	16 Ft. lg.	"
86	1/4" Dia. round gasket	Rubber (Solid)	5 Ft. lg.	"
87	Gasket #28 gage (.0126)	Soft copper	1	"
88	5/8"x5/8" Fillister head capscrew	Bronze	14	45-D-8031
	Wrenches and equipment		See Dwg.	45-D-8041
P	5" Paradox control-complete		1 Unit	45-D-8032
C	Control stand-complete		1 Unit	45-D-8035
V	Air vent breather manifold		1 Unit	45-D-8040
	Rocking sole plate		1 Unit	45-D-8043

LIST OF DRAWINGS

VALVE
- GENERAL ASSEMBLY-LIST OF PARTS 45-D-8022
- LAYOUT DIAGRAM 45-D-8023
- BODY 45-D-8024
- NOZZLE 45-D-8025
- NEEDLE-CONTROL RACK-TUBE AND SPIDER 45-D-8026
- PISTON RING-NOZZLE SEAT AND RETAINERS 45-D-8027
- NEEDLE HEAD AND DIAPHRAGM 45-D-8028
- DIAPHRAGM TUBE-CLAMP-TIP-CAP AND BEARINGS 45-D-8029
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- BOLTS-STUDS-SCREWS-STEMS-SHAFTS 45-D-8031

5" PARADOX CONTROL
- ASSEMBLY-LIST OF PARTS-DRAIN EQUIPMENT 45-D-8032
- CONTROL BODY 45-D-8033
- CONTROL BASE-COVER-LINER-PISTON 45-D-8034

CONTROL STAND-ELECTRIC OR MANUAL OPERATION
- ASSEMBLY-LIST OF PARTS 45-D-8035
- PEDESTAL AND COVER 45-D-8036
- GEARS 45-D-8037
- HANDWHEEL-LIMIT SWITCH PARTS-BUSHINGS-COLLARS 45-D-8038
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AIR VENT BREATHER MANIFOLD
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ROCKING SOLE PLATE 45-D-8043

Figure 6.–Drawing 45-D-8022, general assembly of 72-inch internal differential needle valve.

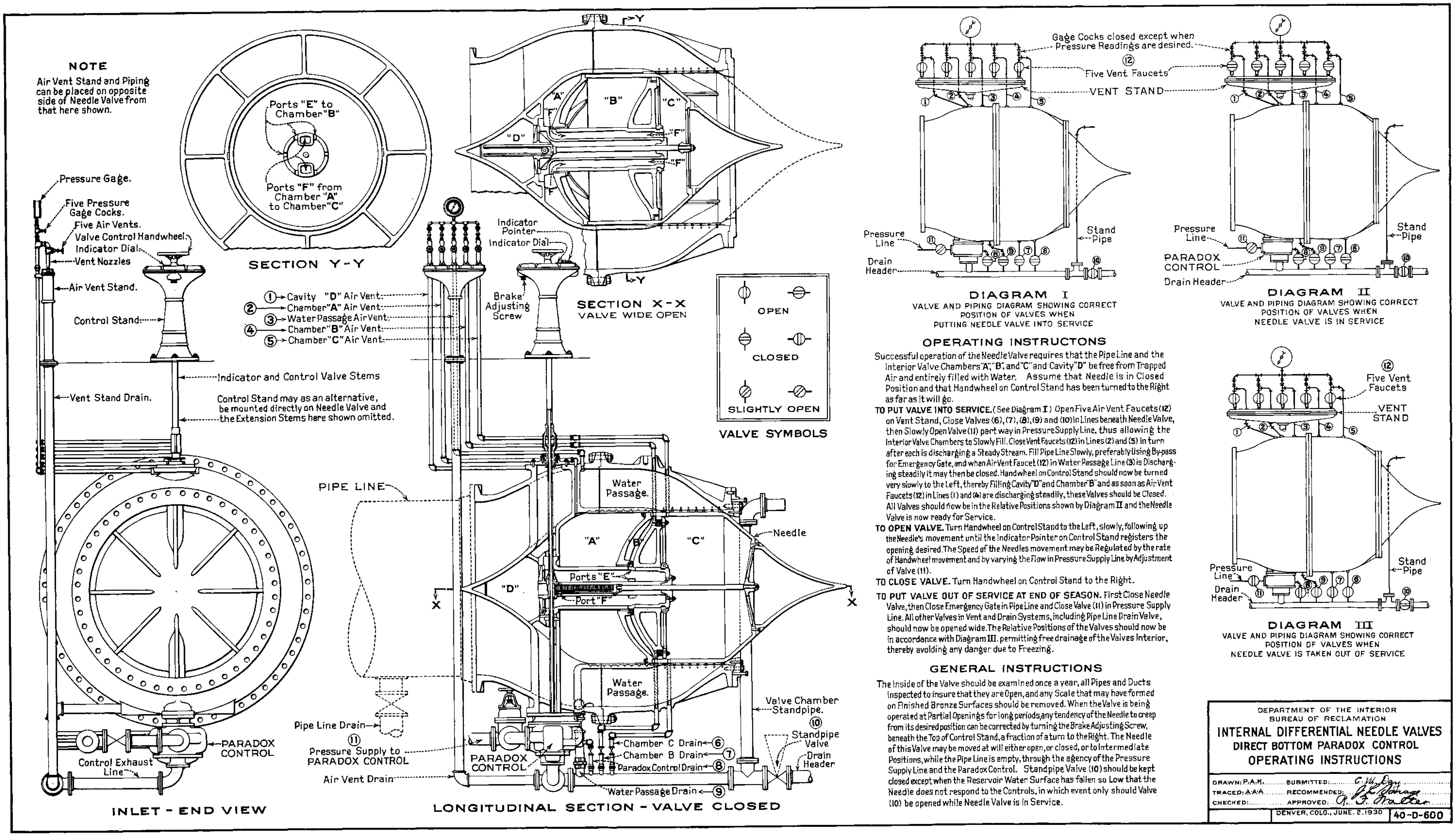
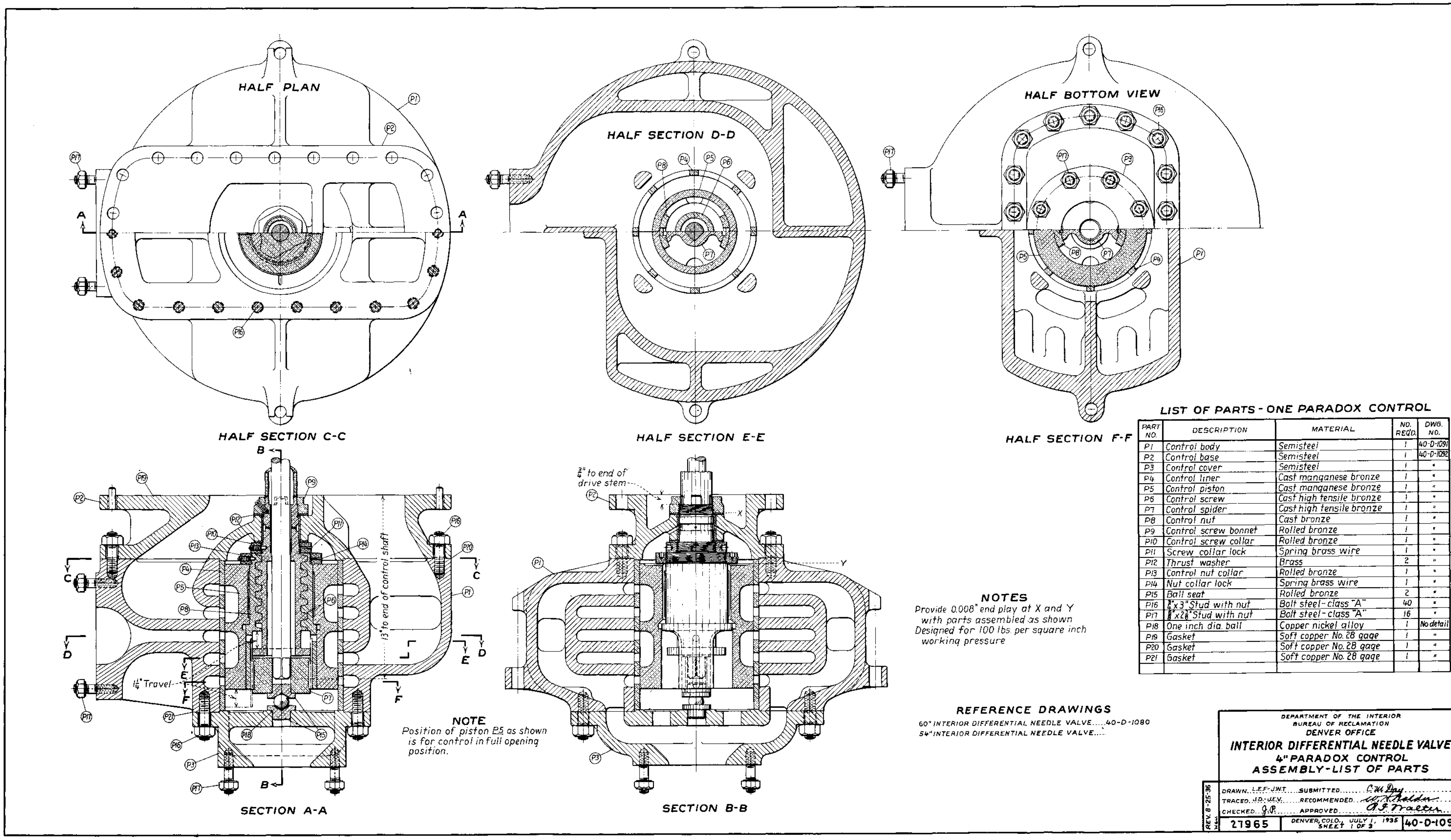


Figure 7.–Drawing 40-D-600, operating instructions for internal differential needle valve.



LIST OF PARTS - ONE PARADOX CONTROL

PART NO.	DESCRIPTION	MATERIAL	NO. REQ'D.	DWG. NO.
P1	Control body	Semisteel	1	40-D-1091
P2	Control base	Semisteel	1	40-D-1092
P3	Control cover	Semisteel	1	"
P4	Control liner	Cast manganese bronze	1	"
P5	Control piston	Cast manganese bronze	1	"
P6	Control screw	Cast high tensile bronze	1	"
P7	Control spider	Cast high tensile bronze	1	"
P8	Control nut	Cast bronze	1	"
P9	Control screw bonnet	Rolled bronze	1	"
P10	Control screw collar	Rolled bronze	1	"
P11	Screw collar lock	Spring brass wire	1	"
P12	Thrust washer	Brass	2	"
P13	Control nut collar	Rolled bronze	1	"
P14	Nut collar lock	Spring brass wire	1	"
P15	Ball seat	Rolled bronze	2	"
P16	¾"x3" Stud with nut	Bolt steel-class "A"	40	"
P17	⅝"x2⅞" Stud with nut	Bolt steel-class "A"	16	"
P18	One inch dia. ball	Copper nickel alloy	1	No detail
P19	Gasket	Soft copper No. 28 gage	1	"
P20	Gasket	Soft copper No. 28 gage	1	"
P21	Gasket	Soft copper No. 28 gage	1	"

DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
DENVER OFFICE
INTERIOR DIFFERENTIAL NEEDLE VALVE
4" PARADOX CONTROL
ASSEMBLY-LIST OF PARTS

DRAWN L.E.F.-J.W.T. SUBMITTED C.M. Day
TRACED J.D.-J.E.V. RECOMMENDED W. H. Nalder
CHECKED J.P. APPROVED A. F. Walter
REV. 8-25-36
27965 DENVER, COLO., JULY 1, 1935 SHEET 1 OF 3 40-D-1090

Figure 8.–Drawing 40-D-1090, assembly of 4-inch paradox control.

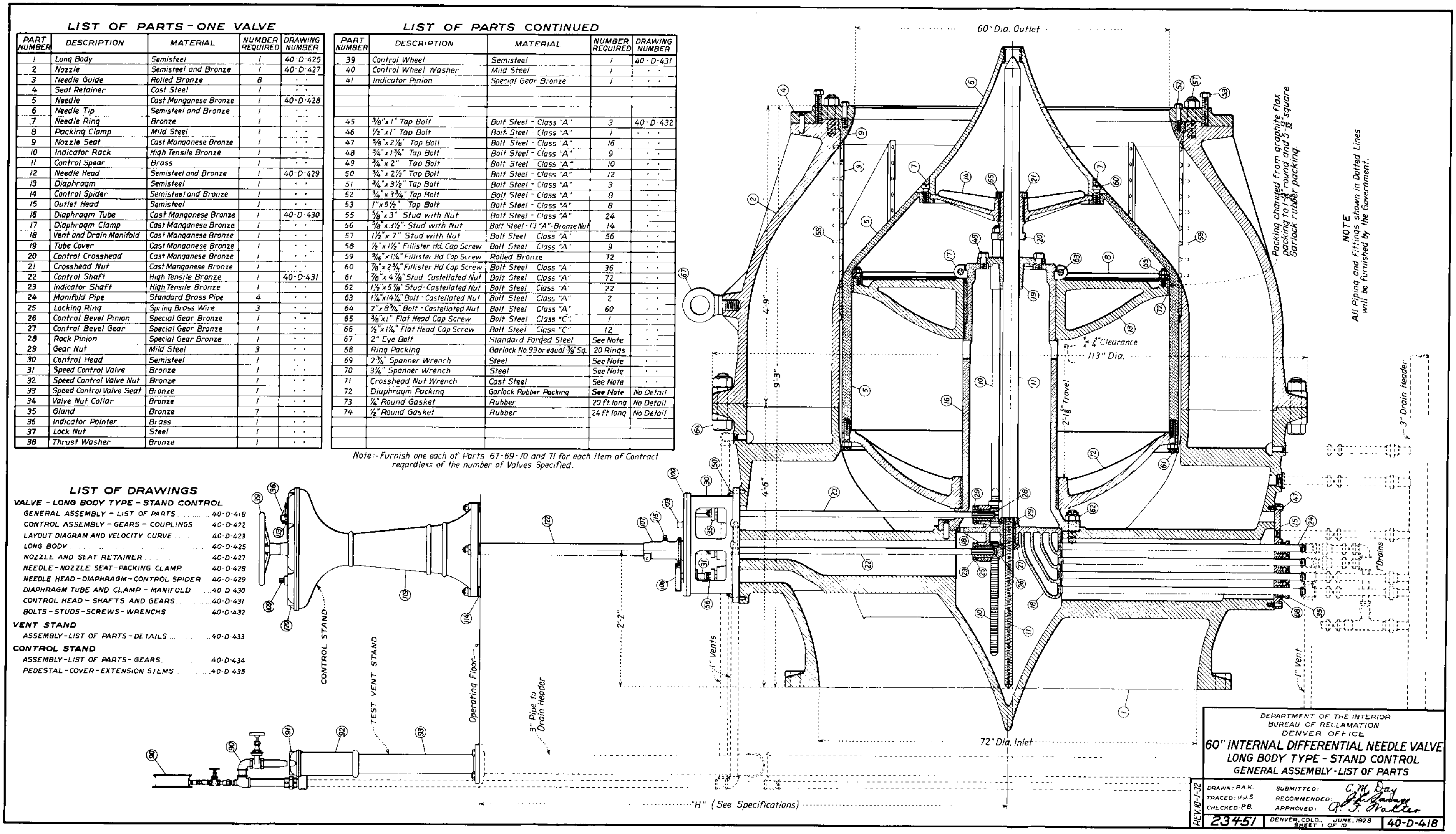
paradox control piston one direction for "open" and the other for "close." This directs water supply to the proper chamber(s) and connects the other chamber(s) to drain producing the desired movement of the needle. As the needle moves, it restores the piston to midtravel stopping both water flow and needle movement. In like manner, if the needle drifts out of position, the paradox control piston is moved producing a flow of water to restore the needle to position.

An internal differential needle valve using a control spear rather than a paradox control is shown in figure 9 (drawing 40-D-418). Figure 10 (drawing 40-D-492) shows the operating instructions for this valve. In this type valve, water at reservoir pressure is present in the opening chamber at all times when the valve is watered-up. A controlled flow of water enters the closing chambers through a built-in clearance between the needle body and the nozzle bushing. A controlled flow of drain water exits the closing chambers through an opening in the center of the needle tip. Flow of the drain is controlled by a spear running through the center of the valve and seating in the needle tip opening. The spear is connected to the control handwheel through a rack and pinion. Turning the handwheel produces lengthwise movement of the spear. Downstream movement of the spear restricts drainage from the closing chambers and increases the water pressure. Upstream movement of the spear increases drainage producing a drop in water pressure in the closing chambers. Since there are two closing chambers and one opening chamber, and reservoir pressure is always present in the opening chamber, the pressure change produced by movement of the spear results in a needle movement in the same direction as the spear.

Interior Differential Needle Valve

Figure 11 is a diagram of the interior differential needle valve showing the arrangement of the principal parts and operating chambers.

Figure 12 (drawing 40-D-2398) shows the general assembly of a 54-inch interior differential needle valve and figure 13 (drawing 40-D-2480) shows the field servicing and operating instructions for this type valve. The physical arrangement of this valve is somewhat different than the internal differential needle valve but the internal chamber arrangement is similar. The needle body on this valve is exterior to the body extension and is attached to a diaphragm tube with an integral diaphragm on the upstream end. This diaphragm slides on and seals against a liner on the inside of the body extension. The body extension has an integral diaphragm on the downstream end which seals against a bronze sleeve on the exterior of the diaphragm tube. This arrangement forms the three internal chambers. Water pressure in the interconnected upstream and downstream chambers produces a closing force on the needle and produces an opening force in the middle chamber. This valve is equipped with a paradox control that functions in the same manner as the paradox control described above for the internal differential needle valve.



LIST OF PARTS - ONE VALVE

PART NUMBER	DESCRIPTION	MATERIAL	NUMBER REQUIRED	DRAWING NUMBER
1	Long Body	Semisteel	1	40-D-425
2	Nozzle	Semisteel and Bronze	1	40-D-427
3	Needle Guide	Rolled Bronze	8	· ·
4	Seat Retainer	Cast Steel	1	· ·
5	Needle	Cast Manganese Bronze	1	40-D-428
6	Needle Tip	Semisteel and Bronze	1	· ·
7	Needle Ring	Bronze	1	· ·
8	Packing Clamp	Mild Steel	1	· ·
9	Nozzle Seat	Cast Manganese Bronze	1	· ·
10	Indicator Rack	High Tensile Bronze	1	· ·
11	Control Spear	Brass	1	· ·
12	Needle Head	Semisteel and Bronze	1	40-D-429
13	Diaphragm	Semisteel	1	· ·
14	Control Spider	Semisteel and Bronze	1	· ·
15	Outlet Head	Semisteel	1	· ·
16	Diaphragm Tube	Cast Manganese Bronze	1	40-D-430
17	Diaphragm Clamp	Cast Manganese Bronze	1	· ·
18	Vent and Drain Manifold	Cast Manganese Bronze	1	· ·
19	Tube Cover	Cast Manganese Bronze	1	· ·
20	Control Crosshead	Cast Manganese Bronze	1	· ·
21	Crosshead Nut	Cast Manganese Bronze	1	· ·
22	Control Shaft	High Tensile Bronze	1	40-D-431
23	Indicator Shaft	High Tensile Bronze	1	· ·
24	Manifold Pipe	Standard Brass Pipe	4	· ·
25	Locking Ring	Spring Brass Wire	3	· ·
26	Control Bevel Pinion	Special Gear Bronze	1	· ·
27	Control Bevel Gear	Special Gear Bronze	1	· ·
28	Rack Pinion	Special Gear Bronze	1	· ·
29	Gear Nut	Mild Steel	3	· ·
30	Control Head	Semisteel	1	· ·
31	Speed Control Valve	Bronze	1	· ·
32	Speed Control Valve Nut	Bronze	1	· ·
33	Speed Control Valve Seat	Bronze	1	· ·
34	Valve Nut Collar	Bronze	1	· ·
35	Gland	Bronze	7	· ·
36	Indicator Pointer	Brass	1	· ·
37	Lock Nut	Steel	1	· ·
38	Thrust Washer	Bronze	1	· ·

LIST OF PARTS CONTINUED

PART NUMBER	DESCRIPTION	MATERIAL	NUMBER REQUIRED	DRAWING NUMBER
39	Control Wheel	Semisteel	1	40-D-431
40	Control Wheel Washer	Mild Steel	1	· ·
41	Indicator Pinion	Special Gear Bronze	1	· ·
45	3/8" x 1" Tap Bolt	Bolt Steel - Class "A"	3	40-D-432
46	1/2" x 1" Tap Bolt	Bolt Steel - Class "A"	1	· ·
47	5/8" x 2 1/8" Tap Bolt	Bolt Steel - Class "A"	16	· ·
48	3/4" x 1 3/4" Tap Bolt	Bolt Steel - Class "A"	9	· ·
49	3/4" x 2" Tap Bolt	Bolt Steel - Class "A"	10	· ·
50	3/4" x 2 1/2" Tap Bolt	Bolt Steel - Class "A"	12	· ·
51	3/4" x 3 1/2" Tap Bolt	Bolt Steel - Class "A"	3	· ·
52	3/4" x 3 3/4" Tap Bolt	Bolt Steel - Class "A"	8	· ·
53	1" x 5 1/2" Tap Bolt	Bolt Steel - Class "A"	8	· ·
55	5/8" x 3" Stud with Nut	Bolt Steel - Class "A"	24	· ·
56	5/8" x 3 1/2" - Stud with Nut	Bolt Steel - Cl. "A" - Bronze Nut	14	· ·
57	1 1/2" x 7" Stud with Nut	Bolt Steel Class "A"	56	· ·
58	1/2" x 1 1/2" Fillister Hd. Cap Screw	Bolt Steel Class "A"	9	· ·
59	9/16" x 1 1/4" Fillister Hd. Cap Screw	Rolled Bronze	72	· ·
60	7/8" x 2 3/4" Fillister Hd. Cap Screw	Bolt Steel Class "A"	36	· ·
61	7/8" x 4 7/8" Stud - Castellated Nut	Bolt Steel Class "A"	72	· ·
62	1 1/2" x 5 7/8" Stud - Castellated Nut	Bolt Steel Class "A"	22	· ·
63	1 1/4" x 14 1/4" Bolt - Castellated Nut	Bolt Steel Class "A"	2	· ·
64	2" x 8 3/4" Bolt - Castellated Nut	Bolt Steel Class "A"	60	· ·
65	3/8" x 1" Flat Head Cap Screw	Bolt Steel Class "C"	1	· ·
66	1/2" x 1 1/4" Flat Head Cap Screw	Bolt Steel Class "C"	12	· ·
67	2" Eye Bolt	Standard Forged Steel	See Note	· ·
68	Ring Packing	Garlock No. 99 or equal 3/8" Sq.	20 Rings	· ·
69	2 3/4" Spanner Wrench	Steel	See Note	· ·
70	3 1/4" Spanner Wrench	Steel	See Note	· ·
71	Crosshead Nut Wrench	Cast Steel	See Note	· ·
72	Diaphragm Packing	Garlock Rubber Packing	See Note	No Detail
73	1/4" Round Gasket	Rubber	20 ft. long	No Detail
74	1/2" Round Gasket	Rubber	24 ft. long	No Detail

Note:- Furnish one each of Parts 67-69-70 and 71 for each Item of Contract regardless of the number of Valves Specified.

LIST OF DRAWINGS

VALVE - LONG BODY TYPE - STAND CONTROL	
GENERAL ASSEMBLY - LIST OF PARTS	40-D-418
CONTROL ASSEMBLY - GEARS - COUPLINGS	40-D-422
LAYOUT DIAGRAM AND VELOCITY CURVE	40-D-423
LONG BODY	40-D-425
NOZZLE AND SEAT RETAINER	40-D-427
NEEDLE - NOZZLE SEAT - PACKING CLAMP	40-D-428
NEEDLE HEAD - DIAPHRAGM - CONTROL SPIDER	40-D-429
DIAPHRAGM TUBE AND CLAMP - MANIFOLD	40-D-430
CONTROL HEAD - SHAFTS AND GEARS	40-D-431
BOLTS - STUDS - SCREWS - WRENCHS	40-D-432
VENT STAND	
ASSEMBLY - LIST OF PARTS - DETAILS	40-D-433
CONTROL STAND	
ASSEMBLY - LIST OF PARTS - GEARS	40-D-434
PEDESTAL - COVER - EXTENSION STEMS	40-D-435

Figure 9.—Drawing 40-D-418, general assembly of 60-inch internal differential needle valve.

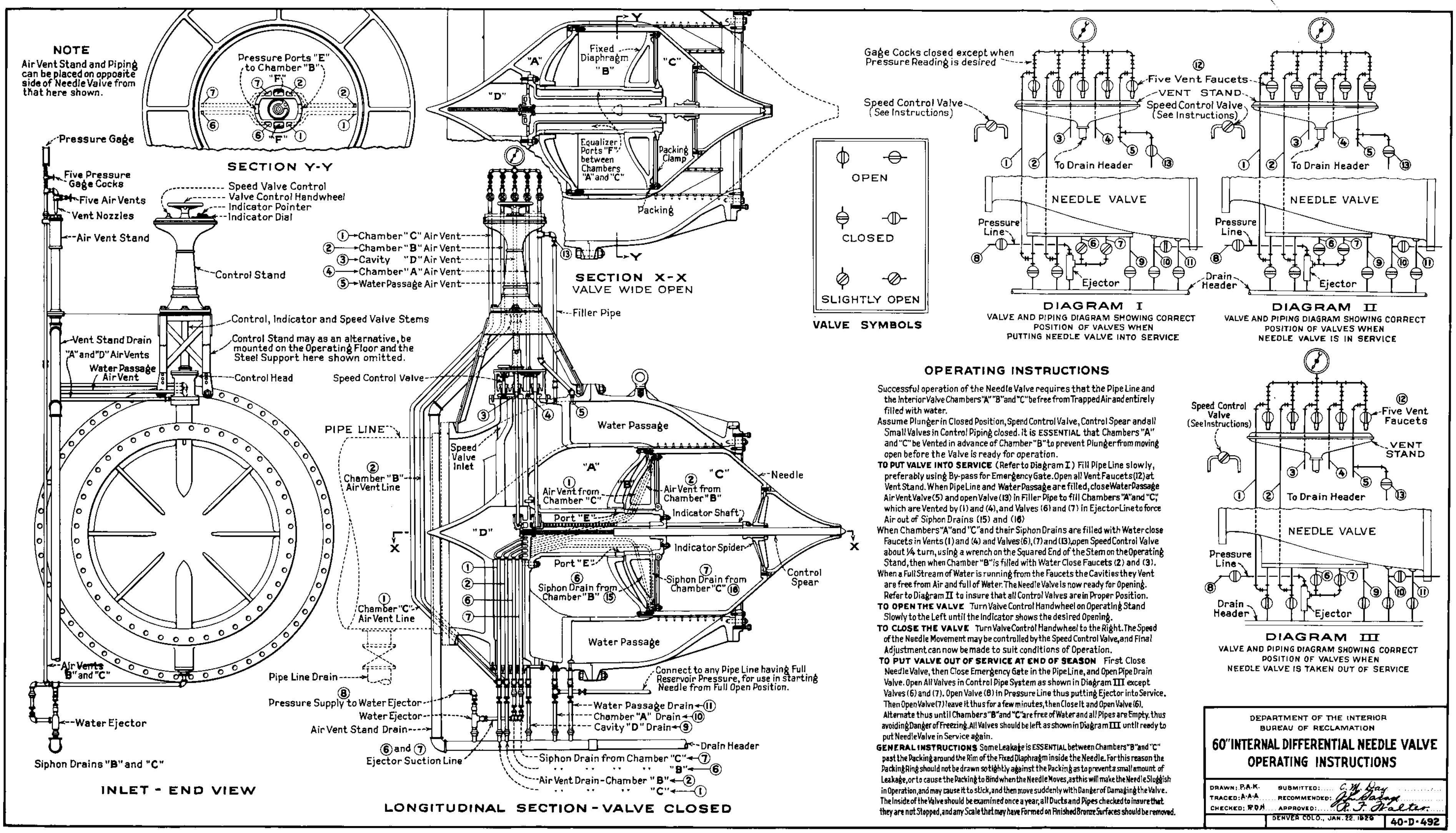


Figure 10.–Drawing 40-D-492, operating instructions for 60-inch internal differential needle valve.

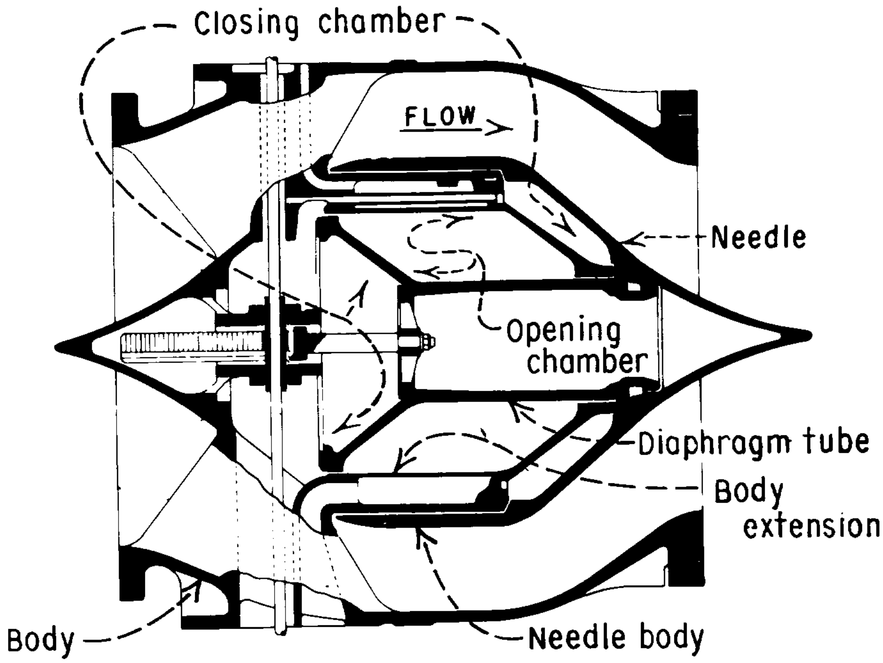


Figure 11.–Interior differential needle valve.

Mechanically Operated Needle Valve

Figure 14 (drawing 40-D-2157) shows the assembly of an 18-inch mechanically operated needle valve. Operation of this valve is straightforward. The needle is driven by a screw located on the centerline of the valve. The screw is driven by a handwheel on top of the valve through a set of bevel gears. A drain is connected to the interior chamber of the valve to dispose of any leakage water.

Minatare Dam Valve

The 24-inch needle regulating valves at Minatare Dam are a "one-of-a-kind" type built about 1922. The assembly of these valves is shown on figure 15 (drawing 20-E-229). Contrary to the general rule for needle valves, the needle and operating mechanism for this valve are at a right angle to the incoming flow. The needle and discharge nozzle are on one side of the body and the mechanical screw type operator is on the other side. A stem is attached to the needle and passes through the body to the operator. A piston is attached to the stem on the operator side to balance the hydraulic load on the needle.

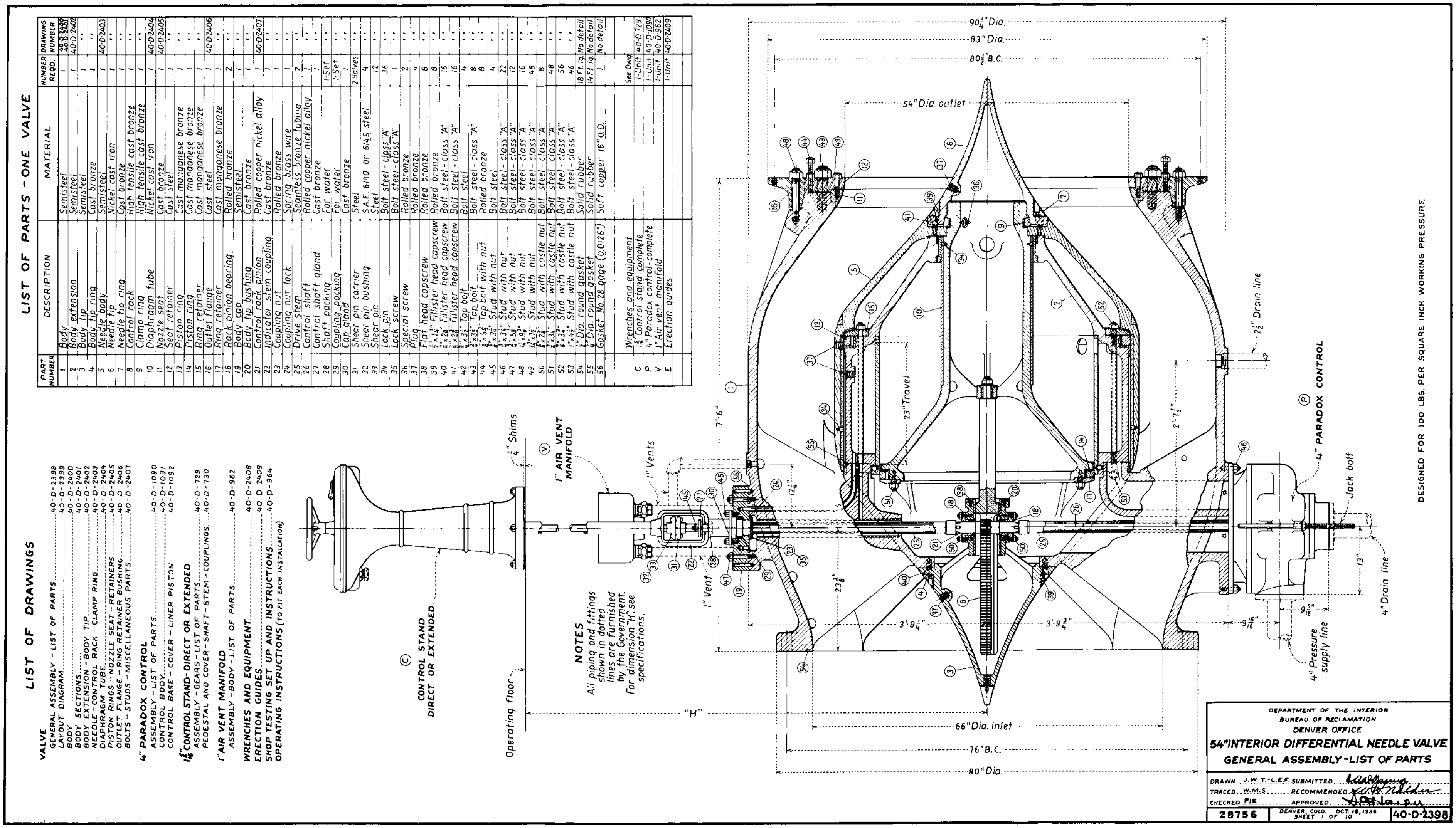


Figure 12.–Drawing 40-D-2398, general assembly of 54-inch interior differential needle valve

IMPORTANT

FOR SEMINOE DAM ONLY - The needle valves shall not be operated when the elevation of the tail water is higher than 6142.5

OPERATING INSTRUCTIONS

I PRE-SERVICING INFORMATION:

A. The Needle can only be moved hydraulically by pressure introduced into chambers **A** and **A'** or **B** through the pressure supply line and the Paradox Control.

B. The function of the handwheel on the Control Stand is to operate the Paradox Control. There is no mechanical connection between the handwheel on the Control Stand and the Needle; therefore, do not attempt to move Needle by twisting the handwheel if the valve is not serviced or if the Needle sticks during operation.

C. Water admitted to the Paradox Control from the pressure supply line should have full reservoir head and should be strained through a screen not coarser than 16 mesh.

D. Proper functioning of the valve requires that the interior chambers **A**, **A'** and **B** in the valve be completely filled with water at all times. The purpose of the Gooseneck is to maintain the water within the valve at the proper elevation.

E. Service valve strictly in accordance with the following instructions.

II TO PUT VALVE INTO SERVICE WHEN THE NEEDLE IS IN THE OPEN POSITION:

A. Rotate handwheel on Control Stand in a counterclockwise direction as far as it will go.

B. Close valves **3** and **5**, and open valve 1 about one-fourth, and fully open valves **2** and **4**

C. Wait until air vent cap on Air Vent Manifold from chamber **B** rises and water begins to flow from valve **4**, then close valves **2** and **4** and the needle valve will be ready for use.

III TO PUT VALVE INTO SERVICE WHEN THE NEEDLE IS IN THE CLOSED POSITION:

A. Rotate handwheel on Control Stand in a clockwise direction as far as it will go.

B. Close valves **3** and **5**, and open valve 1 about one-fourth and fully open valves **2** and **4**.

C. Wait until air vent cap on Air Vent Manifold from chambers **A** and **A'** rises and water begins to flow from valve **4**, then close valves **2** and **4** and the needle valve will be ready for use.

IV TO PUT VALVE INTO SERVICE WHEN THE NEEDLE IS IN INTERMEDIATE POSITION:

A. Rotate handwheel on Control Stand in a clockwise direction as far as it will go.

B. Close valves **3** and **5**, open valve 1 about one-fourth and fully open valves **2** and **4**.

C. Follow any movement of the Needle which may occur with further rotation of the handwheel and watch valve **4**. When water begins to flow from valve **4**, close valves **2** and **4**, and the needle valve will be ready for use.

V TO WITHDRAW VALVE FROM SERVICE WHEN THE NEEDLE IS IN ANY POSITION:

A. Close valve 1 and open valves **2**, **3**, **4**, and **5**.

B. Rotate handwheel on Control Stand in a counterclockwise direction as far as it will go.

C. When water stops running from drain line the interior chambers **A**, **A'**, and **B** will be drained.

VI GENERAL INSTRUCTIONS:

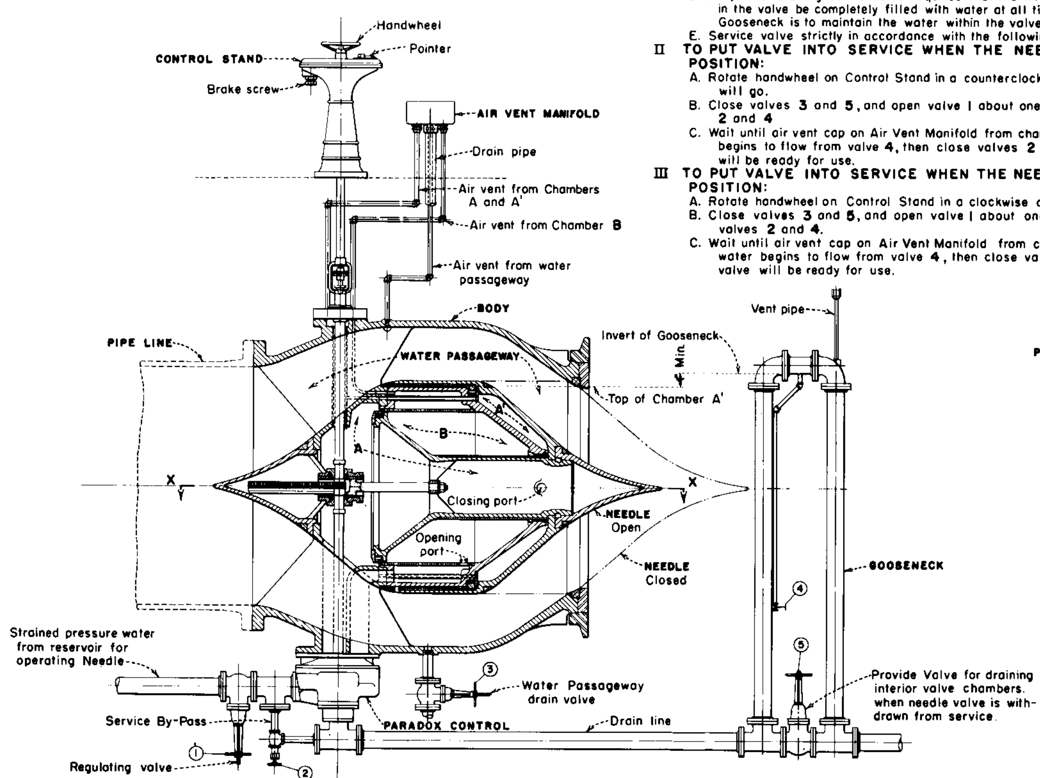
A. To open valve after servicing rotate the handwheel on the Control Stand in a counterclockwise direction. To close valve rotate the handwheel in a clockwise direction.

B. To regulate the speed at which the Needle moves increase or decrease the opening of valve 1.

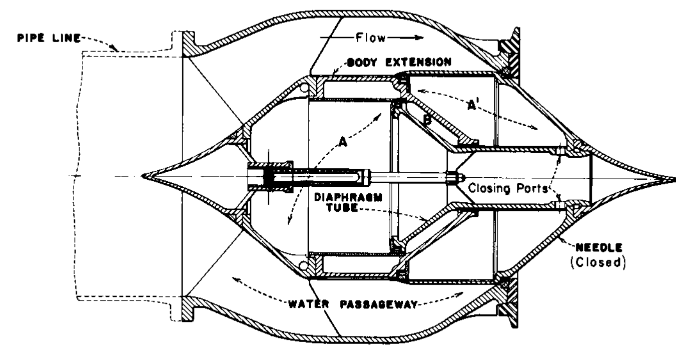
C. Do not mistake the tendency of the Needle to slow down when it nears the fully opened or fully closed position as a tendency to stick. This slowing down is intentionally accomplished due to a constricting of the valve ports.

D. Any tendency of the needle to creep during operation may be corrected by tightening the brake screw on the underside of the Control Stand.

E. After the first year in service, the needle, diaphragm tube and body extension should be removed and inspected for the accumulation of scale on the finished bronze surfaces. Any scale which has formed shall be removed, and the amount of scale present shall be noted and used as a guide in determining advisable future cleaning intervals.



LONGITUDINAL SECTIONAL ELEVATION OF NEEDLE VALVE AND SCHEMATIC ARRANGEMENT OF OPERATING EQUIPMENT



SECTION X-X - VALVE CLOSED

DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
DENVER OFFICE

INTERIOR DIFFERENTIAL NEEDLE VALVE
FIELD SERVICING AND OPERATING INSTRUCTIONS

DRAWN W.H.K. SUBMITTED
TRACED E.W.C. RECOMMENDED
CHECKED W.A.H. APPROVED
DENVER, COLO., JAN. 21, 1937. 40-D-2480

Figure 13.–Drawing 40-D-2480, field servicing and operating instructions of interior differential needle valve.

LIST OF PARTS - ONE VALVE

PART NUMBER	DESCRIPTION	MATERIAL	NUMBER REQUIRED	DRAWING NUMBER
1	Body	Semisteel	1	40-D-2159
2	Operating stem bushing	Rolled bronze	1	40-D-2160
3	Needle stem bushing	Rolled bronze	1	"
4	Needle guide	Rolled bronze	6	"
5	Needle guide	Rolled bronze	2	"
6	Needle body	Cast manganese bronze	1	40-D-2161
7	Needle tip	Semisteel	1	"
8	Needle stem	Rolled bronze	1	"
9	Operating stem	Cold rolled steel	1	"
10	Packing	For water	1 Set	"
11	Gland	Rolled bronze	1	"
12	Seat retainer	Cast steel	1	40-D-2162
13	Nozzle seat	Cast bronze	1	"
14	Bevel gear	Cast manganese bronze	1	"
15	Bevel pinion	Monel metal	1	"
16	Body tip	Cast bronze	1	"
17	Bevel gear nut	Rolled bronze	1	"
18	1¼"x5½" Stud with nut	Bolt steel - class "C"	20	"
19	⅝"x2¼" Needle stud with slotted nut	Bolt steel - class "A"	16	"
20	¾"x3⅛" Seat retainer stud with nut	Bolt steel - class "A"	28	"
21	½"x1⅛" Tap bolt	Bolt steel - class "A"	7	"
22	⅝"x2⅛" Pushoff bolt	Bolt steel - class "A"	7	"
23	¼"x⅝" Round head capscrew	Rolled bronze	36	"
24	¼"x¾" Round head capscrew	Rolled bronze	18	"
25	⅜"x⅞" Flat head capscrew	Rolled bronze	8	No detail
26	4¼" O.D.x2¾" I.D.x$\frac{1}{32}$" thick gasket	Soft copper	1	No detail
27	¼" Dia. gasket	Solid rubber	6½ Feet	No detail
C	Control stand - complete		1 Unit	40-D-2163

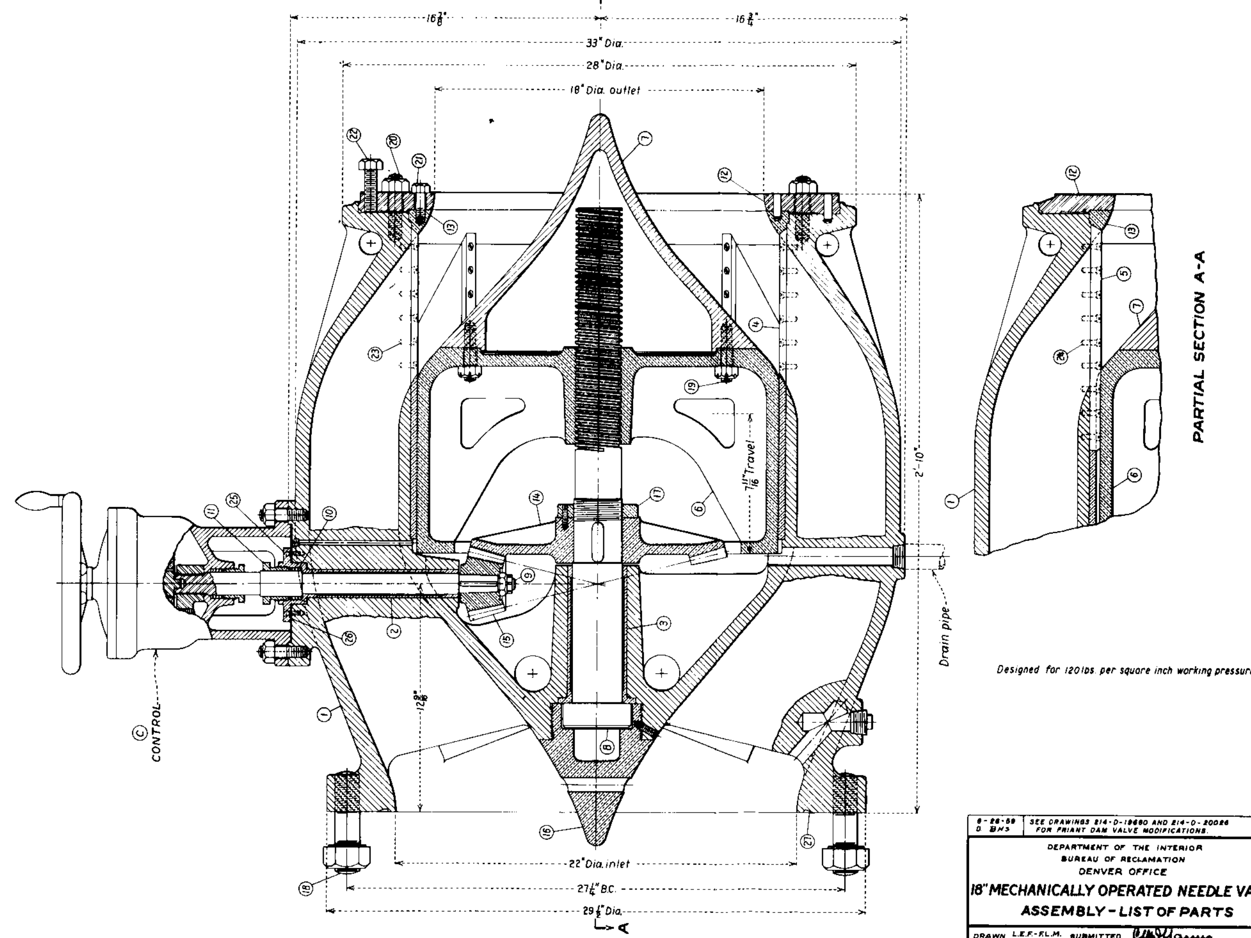
LIST OF DRAWINGS

VALVE

ASSEMBLY - LIST OF PARTS 40-D-2157
LAYOUT DIAGRAM 40-D-2158
BODY 40-D-2159
BODY SECTIONS - BUSHINGS - NEEDLE GUIDES 40-D-2160
NEEDLE - NEEDLE STEM - OPERATING STEM 40-D-2161
NEEDLE SEAT - RETAINER - BEVEL GEARS - STUDS 40-D-2162

CONTROL STAND

ASSEMBLY - BODY - GEARS - LIST OF PARTS 40-D-2163



8-26-59 D BHS | SEE DRAWINGS 214-D-19660 AND 214-D-20026 FOR FRIANT DAM VALVE MODIFICATIONS.

DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
DENVER OFFICE

18" MECHANICALLY OPERATED NEEDLE VALVE
ASSEMBLY - LIST OF PARTS

DRAWN L.E.F.-F.L.M. SUBMITTED ....
TRACED J.E.V. RECOMMENDED ....
CHECKED ....APPROVED ....

DENVER, COLO., FEB 6, 1935 SHEET 1 OF 6 | 40-D-2157

Figure 14.—Drawing 40-D-2157, assembly of 18-inch mechanically operated needle valve.

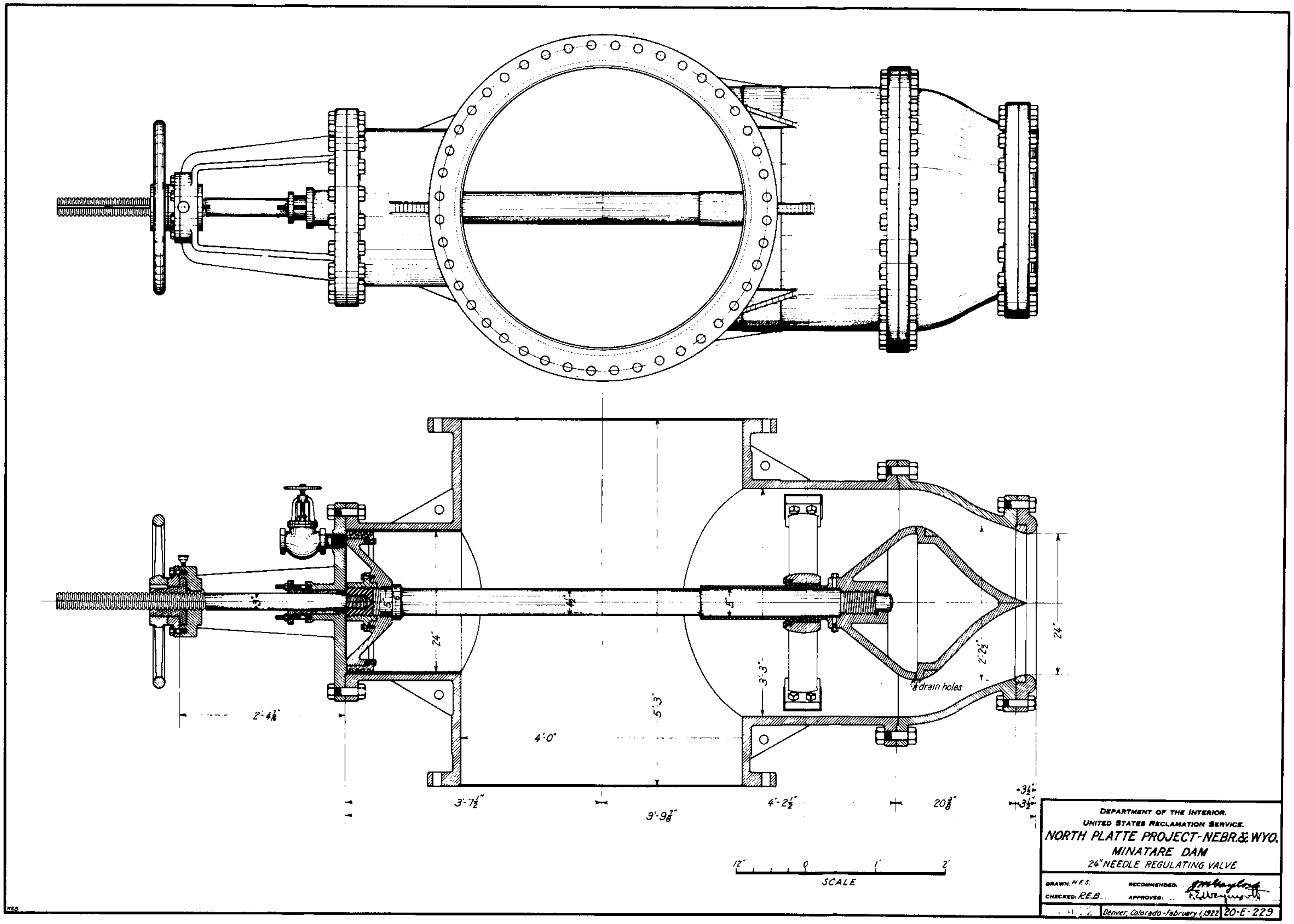


Figure 15.–Drawing 20-E-229, Minatare Dam 24-inch needle regulating valve.

OPERATION AND MAINTENANCE PROBLEMS

General

This section identifies the problems most often reported in the operation and maintenance of needle valves. The problems, underlying causes, and the characteristics of the valves are discussed in detail. Corrective action is stated only in general terms. Recommended operating practices and repair procedures are covered in detail in the following sections.

Operating personnel should be sensitive to changes in valve action. Any change from normal is an indication that maintenance will soon be required. Continuing neglect can result in complete failure of the valve to operate. A malfunction is usually not limited to one problem, but is a combination of two or more. If a valve is disassembled to correct one problem, it should be given a complete overhaul to correct all deficiencies.

A study of the operating chamber arrangement on all types of water-operated needle valves reveals that the designers provided a larger force to close the valves than to open. What was not a design consideration but did add an extra closing force is a subatmospheric pressure created on the needle by the discharging water. As a result, difficulties with the valves will often appear first during the opening cycle rather than the closing. The needle on any of these valves is held in an intermediate position only by a balance of hydraulic forces and the friction load on needle. The position is not positively held as it would be on a mechanical valve, but is influenced by any condition that upsets the balance of hydraulic forces.

Any problem with these valves will be more pronounced at low reservoir. The hydraulic forces operating the needle decrease in proportion to the decrease in available head. If poor operation at low reservoir is due only to the loss of head, a booster pump can be installed in the supply line to increase the effective head. The boost pressure must be limited to the design head of the valve. A booster pump should not be used at normal heads or in an effort to overcome other problems and delay needed maintenance.

Drifting and Sluggish Operation

Water-operated needle valves respond to control handwheel movement only as fast as water can flow in and out of the valve chambers, which is somewhat slower than the handwheel can be turned. It is necessary, by experience, to learn the speed at which an individual valve responds. Valve response may be slower at low reservoir. A valve can be termed sluggish only if the response becomes somewhat slower than normal. Any change can be expected to take place slowly over a number of years and may go unnoticed until the response has deteriorated badly.

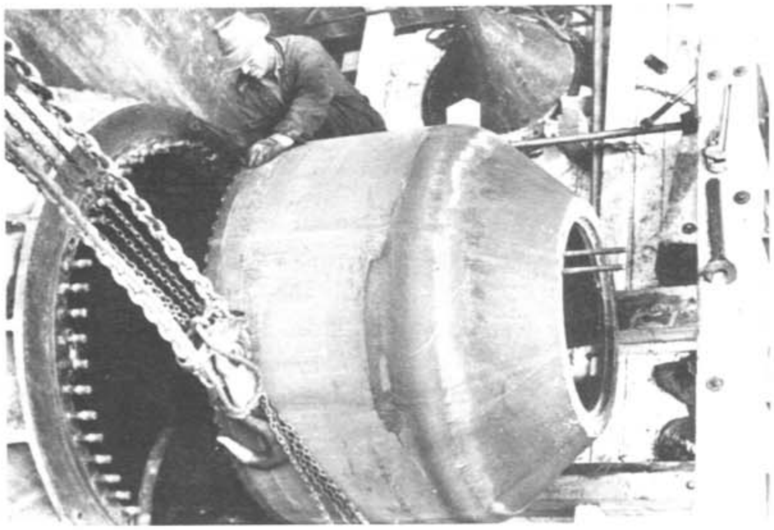


Figure 16.–Removing needle–60-inch internal differential needle valve.

Figure 17.–Body extension after overhaul–54-inch interior differential needle valve.

apparent damage to the metal parts. The black corrosion products are the problem. After they have filled the clearance between parts, they continue to grow forcing the surfaces apart. This puts the outer part in tension and the inner part in compression. The lighter part, usually the bronze part, takes the greater deformation. The stretch or compression in these parts can close off normal working clearances or even break the weaker part. To check for this condition, the needle valve must be disassembled and all surfaces in sliding contact thoroughly cleaned of scale and other foreign material. Then the diameter of these surfaces must be accurately measured. If the measurements indicate a change from the drawing dimensions in some parts, these parts and mating parts must be disassembled as required to remove the corrosion products. Removal of the products will restore original clearances.

Silt and Trash

Silt and trash deposited in water-supply lines and in interior water passages of needle valves interfere with control waterflow slowing down the needle movement. Filters in supply lines must be regularly cleaned and maintained in good condition. A filter can be added if it was not originally provided. Silt should be flushed from the supply line and the valve interior on a regular basis.

Cavitation

Loss of metal from the surface of needle valve parts can be caused by the action of the flowing water. Two conditions often encountered are termed erosion and cavitation. Erosion is normally identified by a rather even loss of surface metal over a given area or can be a definite pathway cut on the mating surfaces of seats or other closely fitting parts. Cavitation damage is characterized by a pitted, uneven appearance. Erosion is normally the lesser problem and the repair of eroded surfaces is much the same as repair of cavitation damage. On many needle valves, cavitation damage is a major problem.

The principles of cavitation were poorly understood when most of the needle valves were designed. Laboratory studies made in about 1940 established design criteria to avoid cavitation damage in needle valves. These criteria were used in the design of the Friant Dam valves, but older valves are subject to cavitation problems.

Cavitation is produced by high velocity waterflow over a surface when the surface contour is such that negative (subatmospheric) pressures occur. The resulting loss of metal from the surface is referred to herein as cavitation damage. The laboratory tests established the following three considerations to be necessary to maintain positive pressures in a needle valve: (1) the angle between the needle and nozzle must not be diverging; (2) the nozzle should have a sharp-edged exit; and (3) the seating point of the needle must be on the cone portion. Since these considerations had not been established when all but the Friant Dam valves were designed, a common pattern of cavitation damage can be found on nozzles, needle seats, and needle cones. The potential for cavitation is greater as the flow velocity increases; so it follows that, other considerations being equal, the higher the operating head the greater the damage will be. The appearance of cavitation damage is shown on figure 18. This type damage should not be neglected as it always gets worse and one damaged area will trigger another downstream. Repairs should be made before the damage is too extensive and, as a general rule, before any of the pits are more than 1/4 inch deep. On thin and sensitive parts, it should be sooner.

Repair of cavitation damage normally involves one or a combination of the following: (1) modification; (2) replacement of parts; or (3) welding repair. Modification is a desirable approach as the potential for cavitation can be reduced but it is normally the most expensive and decreases the discharge capacity of the valve. Modification should follow the three considerations stated above. The nozzle seat should be replaced with one giving both convergence and a sharp exit. Sometimes the needle seat can be built up with weld metal and refinished to improve the contour. Badly cavitated parts can be replaced, but often it is more economical to repair by welding. Again, if the contour of replacement parts or weld repaired parts can be improved, this should be done.

Parts Breakage

Parts breakage can occur from many reasons but is usually caused by some unusual condition that produces shock or overload. Proper maintenance and good operating practices will largely eliminate this problem. Care must be used in filling and venting the valve chambers; in particular, this is true of the older valves which are filled from the water passage.

Zinc bronzes are subject to dezincification in the presence of water. This can result in cracking and breakage of parts, in particular, bolts, even when there is no overload or shock involved. Zinc bronzes should not be used on these valves.

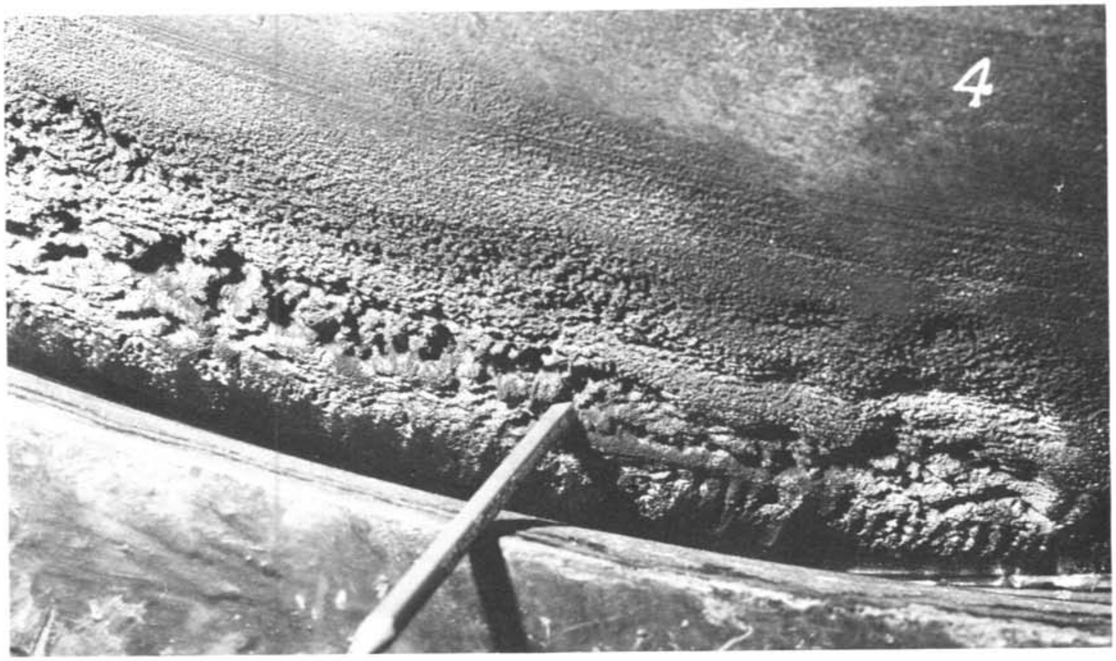


Figure 18.–Cavitation damage on needle–80-inch interior differential needle valve.

RECOMMENDED OPERATING PRACTICES

General

Good operating practices and regular preventive maintenance can prevent or delay the need for major repairs.

Remember that needle valves are operated by hydraulic forces. The handwheel controls only the flow of control water and has no mechanical link to the needle. A handwheel should never be forced as this can only result in a broken shear pin. Allow the needle to move at its own speed and follow at the same pace with the handwheel. Never replace the shear pin with one of higher strength material as it is there to protect other parts of the control from overload.

On interior and internal differential needle valves with paradox controls, proper adjustment of the brake on the control stand will help to prevent valve drifting when other operating conditions are met. Adjustments should be made in small increments.

Exercising Valves

Regular exercising of any type equipment is required to keep moving parts free and operating properly. This is especially true of needle valves. All the moving parts are in contact with water and subject to scale and other deposits which are very detrimental to good operation. Frequent exercising will remove most of these deposits and otherwise keep the needle movement free. It is important to operate through full travel. All needle valves should be exercised twice a year by operating from closed to fully open and back to closed.

Flushing Valve Interiors

The interior needle valve chambers and control water passages should normally be flushed once a year to remove silt and other foreign material. However, the need varies according to the silt load in the water, and at installations with a light load, flushing can be less frequent. Where the silt load is heavy, flushing may be required twice a year. The water-supply line should be flushed at the same time.

It is best to do the flushing as soon as practicable after taking a valve out of service to give the silty mud less time to dry and cake. Use a pressure base to reach all possible interior passages and chambers. As appropriate for each valve, remove the control unit and any manhole covers. Work through these and any other available openings into the valve. Flushing should also be done through vent, drain, and pressure connections into areas that cannot otherwise be reached.

Flush the supply line with reservoir water. If an opening is not available to release the flush water, a tee should be installed. Usually this can be done by replacing an elbow just ahead of the control unit.

Filling Valve Chambers

Care must always be used when filling the needle valve chambers. If these chambers fill unequally and water pressure starts to build up in only one chamber, an unbalanced force will be placed on the needle. This force can produce unexpected movement of the needle and a shock on internal parts which may cause damage or breakage. Always fill slowly so that chambers can fill as evenly as possible. Keep air vents open until all chambers are filled to prevent unequal pressure buildup.

The interior and internal differential needle valves present no unusual filling problem as long as the instructions are carefully followed. Never open filling valves more than specified in the operating instructions. They can be opened a lesser amount for slower filling. Be sure the air vents are open and working properly.

The balanced needle valves present a special filling problem as they do not have separate filling lines but are filled directly from the water passage. This requires that the valves be in the closed position when drained and filled. It also means that a large space must be filled (the pipeline downstream from the guard gate and the water passage of the valve) so that the temptation to fill too fast is great. Compounding this problem is the situation that the opening chamber fills much faster than the closing chamber. This all adds up to "FILL SLOWLY" and keep air vents open. Just cracking the filling valve open and allowing overnight for filling is recommended.

Unusual Conditions

In the event of some unusual occurrence, such as an abnormal noise from the valve which might indicate a broken part or for any reason control of the valve is lost, the control handwheel should be turned as far as possible in the closing direction (clockwise). This can prevent further damage to the valve and uncontrolled flow from the outlet.

When sluggish operation of a needle valve occurs due to low reservoir head, the valve operation can sometimes be helped by opening the proper drain valve. For needle valves with paradox controls, this is the drain valve bypassing the gooseneck. For other needle valves, it is necessary to study the drawings and the diagrams on the operating instructions to determine which drain valve will aid the desired needle movement. The drain valve should be opened only when the needle valve opening is being changed and should be closed as soon as the new setting is reached.

At the end of the irrigation season, the reservoir water pressure at some dams is insufficient to close balanced needle valves. The following procedure was developed as an employee suggestion for use at McKay Dam and could be used on other valves having a sleeve-type control unit. (Previously the needle was closed by removing the control unit, entering the valve chamber and forcing the needle closed with jacks.) A separate pressure water supply must be brought to the valve by a pressure hose. If reservoir water is used, valve closure will need to wait for a rise in reservoir level unless a small booster pump is installed in the water-supply line. Boost pressure must be limited to the design pressure of the valve. Proceed as follows:

1. Remove the control cylinder cover and related parts.

2. Remove the inner control sleeve and control shaft.

3. Turn the outer control sleeve so that the opening matches the drain and close the drain valve.

4. Provide and install a specially made plate in place of the control cylinder cover. This plate must be provided with a tap for attaching the water-supply hose.

5. Open the pitot valve halfway.

6. Attach the water-supply hose and fill and vent the needle valve chamber.

7. When the chamber is full, slowly close the pitot valve until the needle moves.

8. With the needle valve closed, shut off water supply, drain the valve, and restore to normal condition.

REPAIR PROCEDURES

Cleaning and Descaling

The first action to be taken after disassembly of a needle valve or control unit for inspection or repair is thorough cleaning and descaling. All silt and other foreign material should be cleaned from the interior surfaces with particular attention being given to ports and water passages between chambers. All scale on contact surfaces must be removed to bright metal.

Scale is difficult to remove and certain safety precautions must be taken. Acid descaling has been tried but it leaves a hard residue which still must be removed by mechanical means. Sanding with wet or dry paper of 200-300 grit is a recommended procedure. Care must be used not to oversand and remove metal but to stop as soon as bright metal appears. Dust from this procedure is highly toxic and must not be breathed. In addition to the use of normal safety equipment and procedures, the working surfaces must be kept wet. The residue will then be a thin mud rather than dust and can be more safely disposed. Contact of the residue with the skin must be prevented.

Surfaces in Sliding Contact

After the sliding contact surfaces on the interior ot the needle valves have been cleaned and descaled, the diameter of mating parts should be carefully measured and the clearance between parts calculated. Because larger parts may distort due to their own weight, they should be positioned to minimize this problem. Make several crisscross measurements to determine the average diameter and the amount of out-of-roundness. Use dial indicators mounted on a swinging axis to check for distortion in large cylinders. The actual dimensions of parts are not as important as the clearance between mating parts. The clearance should be in the range specified on the drawings; it should not be greater or less.

When the clearance is less than the drawing range, a buildup of galvanic corrosion products in the interface between the bronze parts and mating ferrous parts is indicated. These corrosion products will cause expansion of bull rings and similar parts and shrinkage of sleeves and liners. This distortion will be relieved when the corrosion products are removed. The bronze parts must be disassembled from the mating ferrous parts. It can be expected that the fit will be very tight and force will be required. All corrosion products must be removed from the mating surfaces. Reassemble the parts coating the mating surfaces with a product designed to minimize seizing and to exclude water, such as Armite Labs No. 25, Led-Plate, or other similar product. By excluding water from the interface, future galvanic corrosion can be prevented.

When the clearance is greater than that specified on the drawings, one of the parts must be replaced or repaired as described under "Repairing or Replacing Parts," page 33, and turned to restore proper clearance. If the mating part is enough out-of-round to prevent restoring of the proper clearance, it must first be bored or turned as lightly as possible to restore roundness. The use of field boring bars may be necessary where valve bodies are encased in the concrete valve house walls.

Another problem often discovered on valve disassembly is stuck piston rings. These will stick in a compressed position but when freed will expand back to normal. The ring and groove must be cleaned and the groove width increased to provide more freedom of ring movement. This can be done by turning about 0.010-inch from the side of the groove or by shimming the ring retainer an equal amount.

Paradox Controls

Problems with paradox control units (figure 8, drawing 40-D-1090) are normally caused by wear on the mating, sliding surfaces of the control liner and the control piston. Good appearance of these units can be misleading. Measurements of the lands on the piston and the inside diameter of the liner must be carefully made and the clearance calculated. Make measurements at three equally spaced diameters on each land and at enough places on the inside of the liner to detect worn areas. Normally the heaviest wear will occur on the center land of the piston and good fit on this land is critical to good performance.

When the measurements show wear on these parts, the clearance between the liner and piston must be restored to that specified on the original drawings. The clearance can be less as long as there is no binding, but it should not be greater. It is not necessary to hold the exact drawing dimension for the diameter of these parts so long as the correct clearance is restored for the full contact length of the parts.

Both the liner and piston can be replaced with new parts but this is not usually necessary. Normally the most economical repair procedure is: true the inside surface of the liner by machining, build up the piston lands with weld metal, and refinish the piston lands. When refinishing, care must be used to retain concentricity of the parts. The liner should not be removed from the control body for machining and the amount of metal removed should be held to a minimum. Use care to prevent distortion of the piston, particularly when applying weld metal. Mount the piston on a special steel mandrel for welding and machining. Another repair procedure which has been used is to remachine the piston removing just enough metal to true the lands and replace the liner with one bored to match the slightly reduced diameter of the piston.

Cavitation Damage

Figure 19 (drawing 32-D-618), shows modifications to the nozzle seat of a 60-inch balanced needle valve. The modification involves replacement of the damaged (by cavitation) nozzle seat with one having a modified contour and reboring of the seat retainer to match the downstream diameter of the modified seat. The replacement seat is provided with a water passage contour that meets the three considerations established by laboratory tests and set forth on page 38. It has an angle between the needle and nozzle that is converging; it

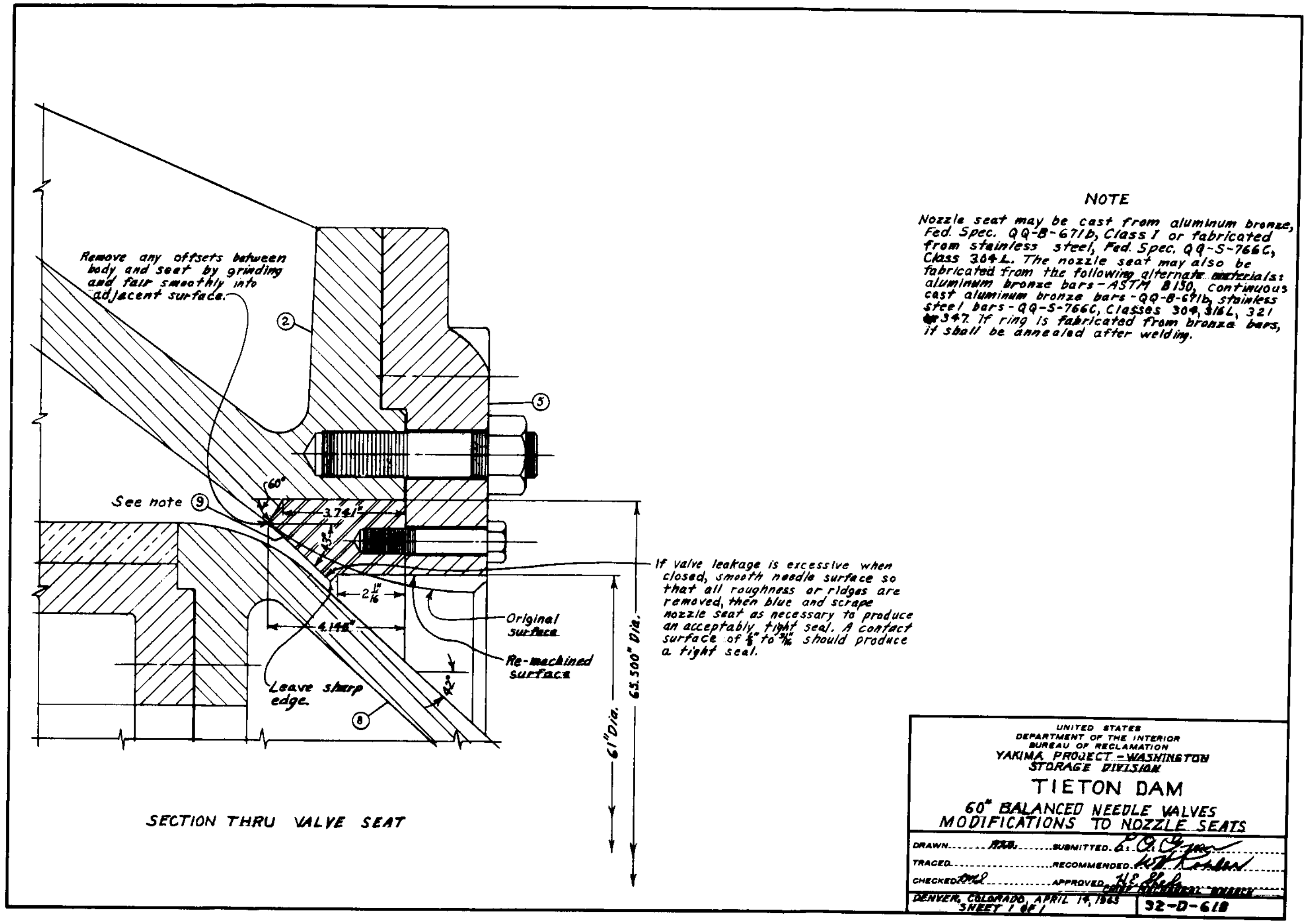


Figure 19.–Drawing 32-D-618, modifications to nozzle seats–60-inch balanced needle valves.

provides a sharp-edged exit; and it seats on the cone portion of the needle. It also provides free access of air to the jet as it leaves the nozzle. This modification should eliminate cavitation damage on the nozzle seat, either eliminate or substantially reduce the damage on the needle seat, and reduce the damage on the needle cone. It does, however, reduce the needle travel resulting in a reduction in the maximum discharge capacity of the needle valve. Unless it is essential to retain the maximum capacity of the valve, this modification should be followed as closely as possible whenever repairs for cavitation damage are made. It is possible that some old seats can be built up with weld metal and remachined to the modified contour rather than being replaced.

Repair of cavitation damage on the needle and similar areas is normally accomplished by building up the surface with weld metal and then grinding back to contour. On some valves, the needle seat can and should be replaced with one of stainless steel or aluminum bronze for added cavitation damage resistance. Before placing weld metal, the damaged surface should be ground or chipped to sound, bright metal. The area to be welded should not be ground to a feather edge, but should have an abrupt shoulder. The welding rod used to build up the overlay must be compatible with the base metal. Aluminum bronze and stainless steel are highly resistant to cavitation damage and should be used when possible. The new metal must be ground to a smooth, even contour. A template (fig. 20) should be used to maintain the proper contour. Any ridges, bumps, or indentations left on the surface will trigger new cavitation.

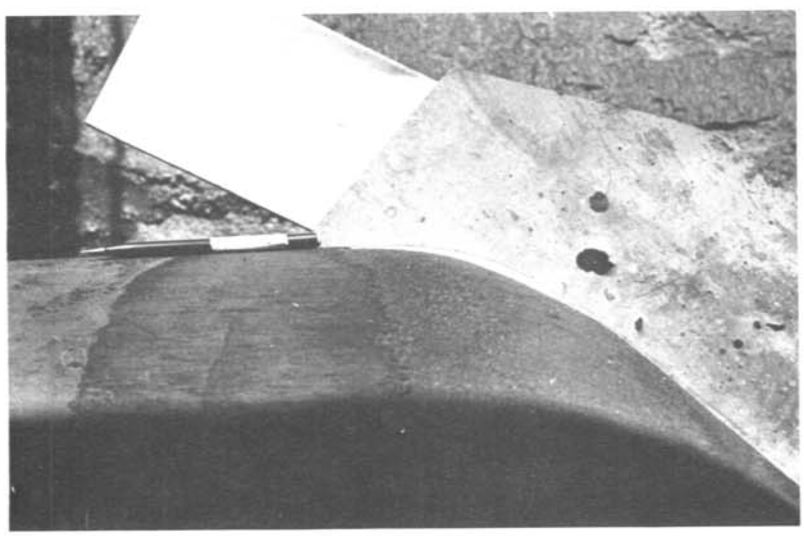


Figure 20.–Checking needle with template–60-inch internal differential needle valve.

Welding

Welding can be used to good advantage in the repair of needle valves and the fabrication of replacement parts. This bulletin does not attempt to give detailed welding information. Power Operation and Maintenance Bulletin No. 24 is an excellent source of general information on welding and, in particular, on the welding repair of cavitation damaged parts.

Care and good welding techniques must always be used to avoid distortion of parts during welding. Fixtures and precautions similar to that described in Power O&M Bulletin No. 24 should be used for needle cones and similar parts where distortion due to welding can occur.

Welding of cast iron should not be done when full strength is required from the part as the parent metal is weakened in the heat affected zone. Weld is normally satisfactory for overlaying cavitated areas and for nonstrength parts.

Welding techniques and capabilities are constantly undergoing improvement. It is well to seek the latest information from the major suppliers of welding rod and equipment concerning the proper rod, technique, etc., to use for any given application.

Repairing or Replacing Parts

Having identified valve parts that are worn or for other reasons are no longer in serviceable condition, one is faced with several choices of repair procedures and materials. Cost is always a major factor but it is more important that the repair be fully effective. Many of the factors involved are discussed here so that a good choice can be made.

Most of the parts on these valves are castings which were a good economical choice at that time. Now casting is normally an expensive choice, particularly when only one part is required. For some parts, a replacement casting may be the most effective repair and should be chosen, but in most cases, economics will rule otherwise. Consideration should always be given to fabrication of new parts by welding. Replacements for cast iron and semisteel parts should, whenever possible, be fabricated from steel as this is not only cost effective, but gives a higher strength part that is easily repaired by welding.

Materials selection is a major consideration. It is not necessary and sometimes not desirable to make a replacement part of the same material as the original. Steel is normally to be preferred over cast iron or semisteel, whether the part is to be cast or fabricated by welding. Steel is more subject to corrosion damage but this is not a serious problem. It is more than offset by the advantages of ductility, higher strength, and ease of weld repairs. In repairing or replacing bronze parts that are in sliding contact, the preferred materials are aluminum bronze sliding on stainless steel. These not only have good properties in sliding contact but both are highly resistant to cavitation damage and easily repaired by welding. Normally only one of the surfaces will need replacing. In this case, stainless steel is preferred but aluminum bronze is entirely satisfactory. The one combination that should be avoided is stainless steel sliding on stainless steel as this combination is subject to galling and seizure. The normally used alloys of aluminum bronze and stainless steel are not as strong as the cast manganese bronze used in many of the original parts. In most cases, they are still satisfactory substitutes, but if full strength is required, a higher strength bronze should be used. Aluminum bronze parts can be cast or fabricated by welding. Stainless steel parts can be cast but normally should be fabricated. Type 304L stainless steel is preferred but types 304, 316L, 321, and 347 are fully satisfactory. One further precaution: do not use zinc bronzes for replacement parts because of the problem of dezincification in contact with water.

In many cases, repair of worn or damaged parts is satisfactory as well as more economical than replacement. Where worn or damaged surfaces must be built up, a weld overlay machined to provide the proper dimension and surface texture is often the best choice. The original surface must be cleaned or machined to sound, bright metal before welding. The overlay should be thick enough so that the final machined surface will be in the weld metal and not in the interface between the weld and parent metals. Normally obtaining this thickness will require machining or grinding metal from the original surface before applying weld metal. The welding rod must be compatible with the parent metal. Stainless steel or aluminum bronze rods are preferred if compatible. Figure 21 (drawing 33-D-3965) shows a procedure used to apply a stainless steel band (ring) on the periphery of a bull ring. This is an effective alternate to a weld overlay and can be used on any similar part. The band could also be fabricated from aluminum bronze. Often it is economical to replace an entire cast ring with a fabrication as shown for the nozzle seat on figure 19 on page 47. This method can be used for any ring of relatively simple cross section made of any weldable material.

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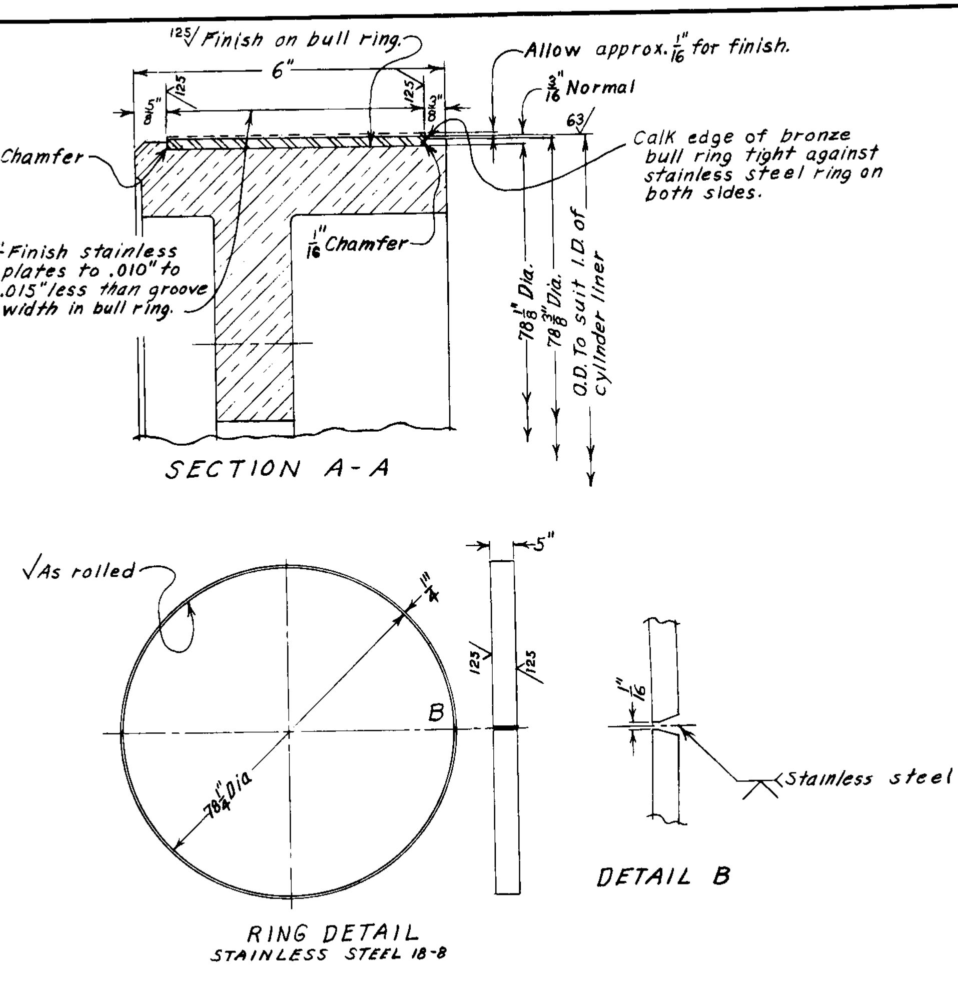

MODIFICATION PROCEDURE

1. Machine a groove in the bull ring, part 21, as shown.
2. Provide stainless steel plates, bent into a ring and machined as shown to fit in the groove of the bull ring. The edges and chamfer should be machined on the plates before bending. Only the edges of the plates require machining.
3. Clamp the stainless steel ring sections tight around the rim of the bull ring. The ring may be clamped down tight by using a series of C-clamps (at least 15 on each side) around the rim, or by using two wire ropes tightened down with turnbuckles, or other means, around the rim of the bull ring.
4. Weld both joints of the stainless steel ring simultaneously so that the ring will shrink to a tight fit around the hub when it cools.
5. Calk the edges of the bull ring tight against the stainless steel ring.
6. Machine the stainless steel ring for proper clearance in the rebored piston cylinder.
7. The three 1/4-inch radius grooves can be eliminated on the stainless steel ring.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
YAKIMA PROJECT-WASHINGTON
TIETON DAM
60-INCH BALANCED NEEDLE VALVE

DRAWN J.S.D. ..... SUBMITTED
TRACED .... RECOMMENDED
CHECKED .... APPROVED
DENVER, COLORADO 11-18-64 33-D-3965
SHEET 1 OF 1

Figure 21.–Drawing 33-D-3965, bull ring–60-inch balanced needle valve.

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